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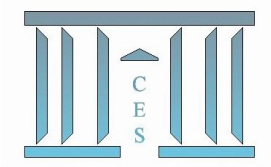

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Large-scale health interventions and education: Evidence from Roll Back Malaria in Africa*

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Abstract

Relying on microeconomic data, we examine the impact of the Roll Back Malaria (RBM) campaigns on the educational attainment of primary schoolchildren across 14 countries in Sub-Saharan Africa. Combining a difference-in-differences approach with an instrumental variables analysis, we exploit exogenous variation in pre-campaign malaria risk and exogenous variation in exposure to the timing and disbursements of the RBM campaign. In 13 of 14 countries, the RBM campaign substantially improved schooling attainment at an average cost of $ 13.19 per additional year, which is highly cost-effective as compared to standard educational interventions.

Keywords: Health, education, Africa, spillovers, quasi-experiment, Roll Back Malaria

JEL: I15, I21, O15

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1 Introduction

Despite decades-long efforts, malaria remains a life-threatening disease. In 2013 alone, there were roughly 198 million cases of malaria, resulting in an estimated 584,000 deaths.[1] For those who survive, malaria also poses a significant challenge to educational attainment. Contracting malaria, especially at a young age, disrupts school attendance and may result in lifelong health and cognitive disorders (Cutler et al. (2010); Bleakley (2010); Lucas (2010); Venkataramani (2012)).[2] Our objective in this paper is to examine the impact of large-scale, contemporaneous malaria control efforts on education. Relying on a microeconomic analysis of unprecedented coverage for 14 countries in Sub-Saharan Africa, we study the medium-term impact (0-10 years) of major anti-malarial campaigns on the educational attainment of primary school students. We find that, even when compared to standard health and educational interventions (Kremer, 2003; Miguel and Kremer, 2004; Kremer and Holla, 2009; Kremer, Miguel and Thornton, 2009), national-level malaria control appears to be a particularly cost-effective strategy to improve educational attainment, with an average cost of roughly $ 13.19 per additional year.

In 1998, the World Health Organization (WHO) launched a new campaign to halve malaria deaths worldwide by 2010 (Nabarro and Tayler, 1998), a target achieved in 2014. With this goal came the need to establish a global framework for coordinated action against malaria — and the Roll Back Malaria (RBM) Partnership was born.[3] Many initiatives arose in support of RBM. Following its formation in 2002, the Global Fund to Fight AIDS, Tuberculosis and Malaria was the largest source of external funding for malaria control. The Global Fund expanded its commitments to malaria control efforts from $68 million disbursed the year of its inception to over $1 billion per year by the late 2000s (see Pigott et al. (2012)). It operates in 47 of the 48 Sub-Saharan African countries.[4] The President's Malaria Initiative, launched in 2005 by President George W. Bush, and the World Bank Booster Program for Malaria Control in Africa entered the fight a few years later, each program contributing significant funds in support of malaria control.

[1] See the World Health Organization's website: http://www.who.int/features/factfiles/malaria/en/.

[2] See also Clarke et al. (2008), Thuilliez et al. (2010), and Nankabirwa et al. (2013).

[3] More information can be found at the website of the Roll Back Malaria Partnership: http://www.rbm.who.int/.

[4] Seychelles is the exception.

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By 2010, external sources were putting forth nearly $2 billion annually for malaria control (Pigott et al., 2012). Sponsored control efforts focus on the treatment of clinical cases as well as on prevention among populations who are the most at-risk through artemisinin-combination therapies (ACTs).[5] They also seek to limit the transmission of the disease from mosquitoes to human beings with insecticide treated nets (ITNs) and indoor residual spraying (IRS).[6] Because they face the most acute symptoms and highest risks of death, the primary targets of most control efforts are children under five and pregnant women. In Zanzibar, for example, Bhattarai et al. (2007) show that RBM-sponsored interventions have indeed allowed for a substantial decrease in infant mortality.

In 14 countries in Sub-Saharan Africa, we first show that malaria has been decreasing since the first disbursements of the RBM malaria control campaigns, particularly in areas where initial malaria risk was highest. Given that malaria control is RBM's main objective, this outcome is to be expected. Bednet and drug usage respond similarly. We provide additional suggestive evidence that infant fever and mortality improve as malaria risk falls, as do educational outcomes. We then turn to our research question by more carefully isolating the impact of the RBM anti-malaria campaigns on the educational attainment of primary school students. Our empirical strategy combines a difference-in-differences approach with an intrumental variables (IV) analysis, similar to several important studies on the effect of historical malaria eradication programs (Cutler et al., 2010; Bleakley, 2010; Lucas, 2010; Venkataramani, 2012).

The difference-in-differences approach exploits variation in pre-campaign malaria risk (as measured by the Malaria Atlas Project) at the Demographic and Health Survey (DHS) cluster level, as well as exogenous variation in children's exposure to the RBM campaign (lifetime disbursements since the start of the campaign). Indeed, as already stressed, evidence suggests that areas with higher pre-campaign malaria risk benefit relatively more from anti-malaria campaigns than areas with lower pre-campaign malaria risk, a pattern already identified by previous papers that have analyzed the impact of mid-twentieth century malaria eradication campaigns. In this setting, DHS clusters with higher pre-campaign malaria risk

[5] Artemisinin and its derivatives are a group of drugs that possess the most rapid action of all current drugs against *P. falciparum* malaria.

[6] These approaches are sometimes combined with larval control which eliminates mosquitoes at their larval stage. However, due to its detrimental environmental effects and poor cost-effectiveness, larval control is recommended only for specific settings.

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are more likely to be treated by the campaign than DHS clusters with lower pre-campaign malaria risks. Moreover, we capture exposure to the treatment by the yearly amount per capita (in USD) disbursed by RBM during a child's lifetime. To do so, we rely on at least two DHS survey rounds per country: one that is pre-campaign or the closest to the campaign's start date and another that is the latest conducted (as of January 2014). Our purpose is to collect information on both children who are unexposed (or barely exposed) and those who are fully exposed. Consequently, exposure to the treatment varies along two dimensions: across age cohorts for a single DHS survey round and across DHS survey rounds for a single age cohort. We present timelines of these countries in Figure 1.

Yet, pre-campaign malaria risk at the DHS cluster level is possibly endogenous. We therefore instrument pre-campaign malaria risk with several standard sets of instrumental variables that rely on geographic, climatic and genetic data (Kiszewski et al., 2004; Bleakley, 2010; Cutler et al., 2010; Burlando, 2012). Our instrumented results are consistent with the original OLS results. We find that, for the average 10 year-old student in our dataset, one more dollar per capita disbursed each year yields, on average, a yearly increase in grade by roughly $ 13.19, making RBM a cost-effective means to increase school participation compared to various other educational interventions (Kremer, 2003; Miguel and Kremer, 2004; Kremer and Holla, 2009; Kremer, Miguel and Thornton, 2009). Our results do not appear to stem from alternative mechanisms. In particular, they are not driven by a mean-reversion effect whereby educational outcomes in DHS clusters in the treatment group converge to those of DHS clusters in the control group before the campaign. Nor are our results biased by individuals' migration from a specific type of cluster to another or specific to the measure of pre-campaign malaria risk that we use.

Large-scale health interventions have the potential to generate important spillovers on education. For example, nation-wide efforts to reduce disease prevalence (e.g. Bleakley (2010); Cutler et al. (2010); Lucas (2010); Venkataramani (2012)) and improve health care (e.g. Jayachandran and Lleras-Muney (2009)) have been shown to boost literacy rates and educational attainment. But pinpointing such effects is not a given (Bleakley, 2010). While healthier children are more capable of learning, increased longevity from better health does not necessarily increase parents' incentives to invest in their offspring's education. On one hand, the longer the stream of payouts, the more valuable the investment. Increased longevity should

therefore translate into more parental investment in education, hence into greater educational attainment (Ben-Porath, 1967; Soares, 2005; Jayachandran and Lleras-Muney, 2009). But, on the other hand, a higher life expectancy affects not only the returns to children's quality but also the returns to their quantity. Greater longevity might therefore result in no increase in the level of education chosen by the parents (Hazan and Zoabi, 2006) and could even reduce income per capita (Acemoglu and Johnson, 2007). Moreover, better childhood health may increase the opportunity cost of going to school, particularly in poor countries, since a healthier child can earn more on the labor market (Bleakley, 2010).

Our paper improves upon the existing literature in at least three ways. First, the scope of our analysis (14 countries and 355,528 students) is unprecedented. While one of the advantages of a quasi-experimental approach over a randomized experiment is that it can be replicated over a larger population, the maximum number of countries covered by previous quasi-experimental studies on malaria is only four (see Bleakley (2010)).[7] Second, contrary to the bulk of previous studies, we do not focus on the malaria periphery, i.e. the set of countries characterized by species of *Plasmodium* (*P. vivax*, *P. ovale* and *P. malariae*) relatively less harmful to health. We concentrate instead on Sub-Saharan Africa where *P. falciparum*, the most aggressive of all species, is dominant. Third, we study contemporaneous, international control efforts. This allows us to make an important distinction from previous analyses that focus on historical malaria eradication in the 1920s-1950s (Bleakley, 2010) and the 1950s (Cutler et al., 2010; Lucas, 2010; Venkataramani, 2012). In this way, we can conduct a cost-effectiveness analysis, which is useful for policy-makers currently involved in improving learning in developing countries. Our findings highlight the importance of evaluating and investing in large-scale health interventions with respect not only to their primary health outcomes but also to their spillover effects on education. As such, they shed further light on the benefits of subsidizing health interventions (Miguel and Kremer, 2004; Cohen and Dupas, 2010; Dupas, 2014; Tanaka, 2014; Cohen, Dupas and Schaner, 2015).

The paper proceeds as follows. In Section 2, we provide suggestive evidence that the RBM malaria control campaigns have decreased malaria risk and hence improved health and educational outcomes in Sub-Saharan Africa. We present our empirical strategy in Section 3. Section 4 displays our results. We discuss our findings in Section 5. Finally,

[7] These four countries are Brazil, Colombia, Mexico and the United States.

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Section 6 summarizes our conclusions and highlights avenues for future research.

2 Suggestive evidence on RBM's effectiveness

In this section, we first show that malaria has been decreasing since the first disbursements of the RBM malaria control campaigns, particularly in areas where initial malaria risk was highest. Bednet and chloroquine usage follow a similar trend. Moreover, we provide tentative evidence that infant fever and mortality improve as malaria prevalence falls, as do educational outcomes.

2.1 Impact on malaria risk

The WHO launched the first worldwide malaria eradication program in 1955. Its strategy centered on spraying houses with residual insecticides, antimalarial drug treatment, and surveillance. However, the most malarious areas, such as Sub-Saharan Africa, were excluded (Alilio, Bygbjerg and Breman, 2004). Newly independent states in Africa thus relied on sponsored efforts at the margin: residual insecticide spraying in urban centers or larvacide in limited areas, national health systems and malaria control programs already operational by the 1950s, hospitals and dispensary-based antimalarial activities, mass drug administration and availability of antimalarial drugs in the open market. The extensive use of residual insecticide dichloro-diphenyl-trichloroethane (DDT) and chloroquine $(CQ)_3$ did benefit Africa as the overall trend of malaria-related deaths showed evidence of decline from the 1950s to 1980s. However, these activities induced the development of both drug and insecticide resistance (Santolamazza et al., 2008). The evolution in Sub-Saharan Africa of the cumulative probability of dying from malaria for children under five[8] is consistent with the emergence of such resistance. As shown in Figure 2, this cumulative probability has indeed been increasing between 1980 and the early 2000s.

Did the first major disbursements of the RBM malaria control campaigns in 2003 counter this trend in Sub-Saharan Africa? Figure 2 depicts a continuous decreasing trend in the cumulative probability of dying from malaria which occurs primarily after the creation of

[8]This cumulative probability refers to the total number of children under five out of 1,000 who are likely to die from malaria in the absence of all other causes. The data come from the Institute for Health Metrics and Evaluation (IHME) at http://www.healthmetricsandevaluation.org/.

the Global Fund in 2002. To provide stronger evidence of an impact of the RBM malaria control campaigns on malaria, we examine the evolution of malaria risk over the 2000-2012 period, on a panel of 120 regions from the 14 Sub-Saharan countries that enter our main analysis.

We proxy for malaria risk by relying on the *P. falciparum* parasite rate (PfPR). This variable is provided by the Malaria Atlas Project for the year 2010.[9] For a given year, it describes the estimated proportion of individuals in the general population who are infected with *P. falciparum* at any given time, averaged over 12 months. These estimates are generated by a geostatistical model that relies on parasite rate surveys as well as bioclimatic and environmental characteristics.[10] As such, the PfPR provides a measure of the intensity of malaria transmission that is both geographically precise and contemporaneous.

Figure 3 plots the mean PfPR for all countries in our sample across the time period 2000-2012. It shows a clear turning point in malaria transmission intensity from the early 2000s. We then plot the change in PfPR while conditioning on the mean initial value of PfPR (in the year 2000) at the regional level. Figure 4a again shows no significant change between 2000 and 2002. Yet, Figures 4b and 4c reveal a striking pattern: the higher the initial level of malaria risk, the stronger the decrease in the periods following the start of disbursements in 2003. Overall, we find suggestive evidence that, not only did the RBM campaign reduce malaria risk, but that this reduction was strongest in regions with the greatest initial malaria burdens.

Does this imply that regions with the highest burdens also benefit the most from malaria control campaigns? We complement our analysis by examining two strategies used in malaria control: the use of bednets for children under five years of age and the use of chloroquine for treating fever in children and pregnant women. While we expect bednet use to increase during this time period, chloroquine use should decrease due to substitution of more effective treatments (ACTs) (Flegg et al., 2013).[11] Figures 5a to 5c plot the change in the use of these strategies between the most recent and earliest DHS rounds against the initial value

[9] The year 2010 is publicly available at http://www.map.ox.ac.uk/browse-resources/endemicity/Pf_mean/world/. We sincerely thank Peter Gething for providing the yearly data (from 2000-2012) through personal communication.

[10] Gething et al. (2011) describe the estimation process.

[11] Malawi was the first African country to replace chloroquine in 1993, followed by Kenya in 1998 and Tanzania in 2000 (see Mohammed et al. (2013)).

of PfPR at the regional level. The plots, in addition to simple regressions, conform to our expectations. This suggests that the most at-risk regions prior to the campaign experienced comparatively larger improvements in malaria control over time.

2.2 Impact on health

The changing risk of malaria over time may have effects on health outcomes. DHS surveys allow us to exploit two health outcomes: the onset of fever within the last two weeks for children under five and the probability for a child born in the five years prior to a given DHS survey to be dead rather than alive at the time of this survey.

We start by analyzing the contemporaneous effect of malaria risk on health outcomes. To do so, we make use of a naturally occurring counterfactual. Several inherited factors influence malaria infection. For example, individuals who carry the sickle cell trait (heterozygotes for the abnormal hemoglobin gene HbS) are relatively protected against severe disease and death caused by *P. falciparum* malaria. The frequency of hemoglobin-related disorders and other blood cell dyscrasias, such as Hemoglobin C, Thalassemia, and glucose-6-phosphate dehydrogenase (G6PD) deficiency, also provide natural protection from malaria.

Two measures of inherited blood disorders are available in the MAP database: the frequency of G6PD deficiency and the frequency of the sickle cell trait. To our knowledge, G6PD deficiency has not been associated with poor educational or cognitive outcomes (Olson et al., 2009) whereas the sickle cell trait has been associated with central nervous system complications (Armstrong et al., 1996). We therefore rely on the frequency of G6PD deficiency at the regional level to proxy for a region's natural protection against malaria. Given that it has no known direct impact on any variables other than malaria risk (Cappellini and Fiorelli, 2008), G6PD deficiency is indeed less at risk of bias from omitted variables when it comes to analyzing the impact of malaria on health and on education (see Section 2.3.).

We measure the contemporaneous effect of malaria risk on health outcomes by relying on Equation (1):

$$\mathrm{y}_{irct} = \alpha + \beta.(\mathrm{LowG6PD}_r \times \mathrm{PfPR}_{rt}) + \gamma.\mathrm{LowG6PD}_r + \delta.\mathrm{PfPR}_{rt} + \mathbf{X_{irct}}'.\mathbf{\Xi} + \phi_r + \phi_c + \phi_t + \epsilon_{irct}. \quad (1)$$

In this equation, y_{irct} is the outcome for individual i in region r who belongs to cohort c

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(the group of individuals born in year c) and is interviewed in year t; $\mathbf{X_{irct}}$ are individual-level controls (gender, age and wealth[12]); ϕ_r are region fixed effects; ϕ_c are cohort fixed effects; and ϕ_t are DHS survey year fixed effects. The variable of interest is the interaction term between LowG6PD$_r$ and PfPR$_{rt}$. Variable LowG6PD$_r$ is binary. It is equal to 1 if region r shows a low prevalence of G6PD deficiency (i.e. its mean prevalence of G6PD deficiency is lower than the mean of all regions) and to 0 otherwise. Variable PfPR$_{rt}$ captures PfPR in region r at date t. The coefficient of the interaction term, β, therefore measures the differential effect of an increase in malaria risk in regions with low relative to high natural protection against malaria risk. We therefore expect a positive sign when y$_{irct}$ stands for fever within the last two weeks or for death probability and a negative sign when y$_{irct}$ captures educational attainment.

When we analyze the impact of malaria on fever, we augment Equation (1) by interacting (LowG6PD$_r$ $\times$ PfPR$_{rt}$) with an indicator for whether the child was surveyed during the rainy season. Similarly, when we analyze the impact of malaria on the probability of death for a child under five, we augment Equation (1) by interacting (LowG6PD$_r$ $\times$ PfPR$_{rt}$) with an indicator for whether the child was surveyed during the rainy season if alive and died during the rainy season if deceased. In both cases, we obviously control for all the subcomponents of the triple interaction term not already included in Equation (1). Because malaria transmission is strongly correlated to wetter weather, we are more likely to isolate fever effects that come from malaria (and not other factors) when we focus on the rainy season. Several studies clearly show that the malaria-attributable fraction of fevers among children and school-age children is higher during the rainy season (Clarke et al., 2004; Dicko et al., 2005; Thuilliez, 2010).

Results are reported in columns 1 and 3 of Table 1. We observe that the coefficient of the triple interaction term is positive and significant. In other words, an increase in malaria risk in historically less protected regions enhances children's morbidity and mortality when the latter are measured during the rainy rather than dry season. This result is consistent with a negative impact of malaria risk on health outcomes. Note that PfPR$_{rt}$ is potentially endogenous: omitted variables, such as a negative shock at date t on household's ability

[12]Wealth is an asset-based index ranging from one (poorest) to five (richest). More precisely, 1 stands for "poorest", 2 for "poorer", 3 for "middle", 4 for "richer", and 5 for "richest".

to adopt preventative antimalarial strategies could increase both children's morbidity and mortality as well as malaria risk. In columns 2 and 4 of Table 1, we therefore provide results that stem from lagging PfPR_{rt} by one year. Our conclusions remain unchanged.

Thus, we can conclude that malaria is detrimental to health outcomes. But do the RBM anti-malaria campaigns counter malaria? Figures 4a to 4c suggest that the most at-risk areas are the main targets of this campaign. Therefore, if the RBM initiative has a positive impact on health outcomes, we should observe an amelioration of these outcomes after the campaign's start date in areas with initially higher levels of PfPR. To test for this hypothesis, we estimate Equation (2):

$$\text{y}_{irctime} = \alpha + \beta.(\text{time} \times \text{PfPR}_{2000}) + \gamma.\text{time} + \delta.\text{PfPR}_{2000} + \mathbf{X_{irct}}'.\mathbf{\Xi} + \phi_r + \text{time}.\phi_r + \phi_c + \epsilon_{irctime}. \tag{2}$$

In Equation (2), the dummy "time" is equal to 1 if a respondent was surveyed during the last DHS round available for a given country and to 0 if he was surveyed during the first DHS round (the one closer to the RBM campaign's start date). Variable PfPR_{2000} captures PfPR in year 2000 at the DHS cluster level. Variable $\text{y}_{irctime}$ is the outcome for individual i in region r who belongs to cohort c and is interviewed during either the first or the last DHS round. The coefficient of the interaction term, β, therefore measures, within a given region, the differential evolution of $\text{y}_{irctime}$ in DHS clusters showing higher relative to lower initial malaria risk. We therefore expect a negative sign when $\text{y}_{irctime}$ stands for fever within the last two weeks or for death probability. By contrast, a positive sign should appear when $\text{y}_{irctime}$ captures educational attainment.

As with Equation (1), Equation (2) is in fact a baseline equation. This means that we augment Equation (2) with a triple interaction term that allows us to measure the marginal effect of the dependent variable during the rainy rather than dry season. Results are reported in columns 1 and 2 of Table 2. They confirm that the coefficient of the triple interaction term is negative and significant, which suggests a positive impact of the RBM campaign on health outcomes.

2.3 Impact on education

The impact of health improvements (through interventions) on education is not obvious. To be sure, reduction in malaria-related morbidity increases children's ability to learn through three main channels. First, malaria during pregnancy can lead to foetal growth retardation which translates into cognitive and physical impairments among children (Barreca, 2010). Second, during early childhood (under the age of five),[13] complicated forms of malaria may develop rapidly. The effects of severe malaria, better known as cerebral malaria, have been quantified by numerous studies.[14] Third, even during late childhood, the protection conferred by acquired immunity is only partial. Clinical malaria can have a non-cognitive impact on educational achievement via school absenteeism, general health conditions, and investment in curative strategies (coping strategies against the disease detrimental to educational investments) (Clarke et al., 2008; Thuilliez et al., 2010; Nankabirwa et al., 2013). However, as previously stressed, better health does not necessarily pave the way for greater educational investments.

We focus in this section on three educational outcomes provided by DHS surveys for children enrolled in primary school: grade level during the current school year, total years of schooling completed and delay status for current grade level. A student is considered delayed if her grade is below the average grade of students of the same age at the national level. We rely on the procedure by Moock and Leslie (1986) to capture delay status. In doing so, we first regress the logarithm of grade on the logarithm of age in each country of our sample. We then estimate the predicted grade level for each individual in each of these countries. Finally, we create a dummy variable that is equal to one if a student's observed grade level is lower than its predicted value.

Columns 5 to 10 of Table 1 report the OLS estimates of coefficient β in Equation (1). They confirm that educational outcomes worsen as malaria levels increase in historically less protected regions. Columns 3 to 5 of Table 2 report the OLS estimates of coefficient β in Equation (2). They reveal that, in a given region, educational outcomes improve between the first and the last DHS round, the higher the initial level of PfPR at the DHS cluster level. These findings not only suggest that malaria risk is detrimental to education but also

[13] Acquired immunity in children does not play an efficient protective role until the age of 5 to 6, even in highly endemic areas. This fact highlights why malaria is a major threat to child survival.

[14] See Mung'ala-Odera, Snow and Newton (2004) for a literature review.

that the RBM anti-malaria campaigns which primarily target the most at-risk areas have a positive effect on educational outcomes.

Note that this impact of health on education may partly capture the influence of health on fertility. Estimates reported in columns 5 to 10 of Table 1 reveal that health improvements increase parents' incentives to invest in their children's education. Put differently, returns to quality increase more than returns to quantity, meaning that parents' target number of live births should decrease (Soares, 2005; Bleakley and Lange, 2009). However, it is unclear whether the total number of live births per woman should ultimately drop, since a decrease in malaria risk might increase the fertility window for women (Lucas, 2013). Despite parents' lower targets of live births, the number of live births may thus raise. Therefore, the number of children alive may also increase: not only does lower malaria risk improve their likelihood of being alive at birth, but it also increases their chances of surviving. In this case, the impact of health on education will be lower than in a situation where parents would be able to meet their lower desired fertility. A higher number of children is indeed known to depress the schooling progress of all children in the family (Rosenzweig and Zhang, 2009).

There is no clear evidence on the relationship between malaria and fertility in Africa. We try to explore this issue by comparing the effects of the campaign on a woman's ideal number of children, her total number of live births and how many of her children are alive. A change in malaria risk might affect households' ideal number of children, without actually translating into a change in the total number of live births or in the number of children alive, at least in the medium-term (0-10 years).

Columns 1 and 3 of Table 3 report the OLS estimates of coefficient β in Equation (1) when we focus on the logarithm of one plus the ideal number of children and the total number of live births for women aged between 15 and 49. Column 5 presents these estimates when the dependent variable is the number of children alive.[15] Columns 7, 8 an 9 of Table 3 report the OLS estimates of coefficient β in Equation (2) for each of these three dependent variables. A contemporaneous increase in malaria risk (column 1) enhances the ideal number of children while a medium-term decrease due to the RBM campaign (column 7) reduces this number. However, this contemporaneous to medium-term variation in malaria risk does

[15] Results presented in columns 1, 3 and 5 are robust to relying on the lagged value of PfPR_{rt} in Equation (1) (see columns 2, 4 and 6 of Table 3).

not translate into a variation in the actual number of births (columns 3 and 8), nor in the number of children alive (columns 5 and 9).

3 Empirical strategy

We now turn to our research question by more carefully isolating the impact of the RBM anti-malaria campaigns on the educational attainment of primary school students. Our empirical strategy combines a difference-in-differences approach with an IV analysis. In this section, we first present our baseline specification. We then explain how we refine this specification in order to address remaining endogeneity issues. Finally, we provide evidence that the parallel trend assumption, the key condition for a difference-in-difference to isolate a causal impact, holds: prior to the RBM campaign, educational outcomes of individuals in the control and in the treatment group do not converge.

3.1 Baseline specification

According to Pigott et al. (2012), the three largest funders of anti-malaria campaigns to date, aside from governments themselves, are the Global Fund (since 2003), the President's Malaria Initiative (since 2006), and the World Bank Booster Program for Malaria Control in Africa (since 2006). Data on disbursements, kindly provided by David Pigott, allow us to construct a measure of exposure to the RBM campaign. This variable captures the yearly amount per capita (at the country level)[16] that these three major funders have disbursed during a child's lifetime. A child's lifetime is defined as the difference between the DHS survey year and this child's year of birth, from which we subtract one year. We consider a child's exposure to begin in utero (though defining the beginning as the year after birth does not alter our results).[17] Variation in exposure of children in a given country therefore

[16] Yearly population data come from the World Development Indicators.

[17] To illustrate the construction of this variable, we take the example of Ethiopia. As reported in Figure 2, the RBM anti-malaria campaigns started in 2003 in Ethiopia. Moreover, three DHS surveys years are available (in 2000, 2005 and 2010). Let's consider a child born in 1999. If this child is surveyed in 2000, she experiences no exposure since the RBM disbursements were to begin only in 2003. If she is surveyed instead in 2005, she experiences three years of exposure to RBM disbursements. Her exposure variable will therefore be equal to the sum of the RBM disbursements per capita during these three years, divided by her lifetime, hence 2005-(1999-1)=7 years. Similarly, if this child is surveyed in 2010, she experiences eight years of exposure to RBM disbursements. Her exposure variable will therefore be equal to the sum of RBM disbursements per capita during these eight years, divided by her lifetime, hence 2010-(1999-1)=12 years.

depends on the variation in DHS rounds and on the variation in children's dates of birth.

We define our difference-in-differences approach in Equation (3):

$$\text{educ}_{ijct} = \alpha + \beta.(\text{exposure}_{ct} \times \text{PfPR}_{2000j}) + \mathbf{X_{ijct}}'.\mathbf{\Gamma} + \delta_j + \delta_c + \delta_t + \epsilon_{ijct}. \quad (3)$$

In Equation (3), educ_{ijct} is an educational outcome[18] of primary school student i in DHS cluster j, who belongs to cohort c and is interviewed in year t; $\mathbf{X_{ijct}}$ are individual-level controls (gender, age and wealth); δ_j are DHS cluster fixed effects; δ_c are cohort fixed effects; and δ_t are DHS survey-year fixed effects. Variable exposure_{ct} stands for the yearly amount per capita (at the country level) that the RBM has disbursed during a child's lifetime, while variable PfPR_{2000j} captures malaria risk in DHS cluster j in 2000, hence prior to the RBM campaign's start date. The coefficient of the interaction term $(\text{exposure}_{ct} \times \text{PfPR}_{2000j})$, denoted by β, should therefore capture the impact of RBM's malaria control on educational attainment.

Note that, for this to be the case, the start of RBM's funding expansion should not have been expected by those affected. If parents anticipated health improvements for their children due to the campaign, they may have been more (or less) dedicated to investing in their children's education, even prior to the campaign's start. Yet it would be difficult for citizens to predict the creation of the major rollout of RBM campaigns, the Global Fund. The Global Fund launched after a series of discussions between donors and multilateral agencies that emerged toward the end of 1999. These discussions notably culminated with the sixth of the eight Millennium Development Goals established following the Millennium Summit of the United Nations in 2000: "To combat HIV/AIDS, malaria, and other diseases." The creation of the Global Fund was therefore not a surprise for donor and multilateral agencies and the limited community of their followers, but it is doubtful that this move was anticipated by the general population of beneficiary countries. Moreover, it is only recently (2011) that this major RBM actor started advertising its actions in developing countries.[19] Hence, even in countries where the Global Fund was not active until a few years after its creation (Sierra

[18] We focus on the three educational outcomes already presented in Section 2.3: grade level during the current school year, total years of schooling completed and delay status for current grade level.

[19] This promotion is based on the green leaf logo of the Affordable Medicines Facility-malaria program (AMFm). This logo is printed on anti-malaria treatments provided by the Global Fund and is notably supposed to reflect price reductions through negotiations of the Global Fund with ACT manufacturers.

Leone and Malawi), the start of anti-malaria campaigns is unlikely to have been anticipated by potential beneficiaries.

Using a difference-in-differences analysis in this way is not new. Other notable studies follow this strategy to analyze the effect of malaria control on various socioeconomic factors. Bleakley (2010) focuses on the malaria control campaigns in the United States (1920) as well as in Brazil, Colombia and Mexico (1950) in order to assess the impact of childhood exposure to malaria on labor productivity. Cutler et al. (2010), Lucas (2010), and Venkataramani (2012) estimate this impact on educational and/or cognitive outcomes in India, Paraguay and Sri Lanka, and Mexico respectively. These studies establish an overall positive impact of control campaigns. Our approach complements these efforts by incorporating detailed contemporaneous data and focusing on control (rather than elimination) efforts.

3.2 Identifying assumptions

For coefficient β in Equation (3) to capture the causal impact of the RBM campaign on educational achievements, the interaction term ($\text{exposure}_{ct} \times \text{PfPR}_{2000j}$) must be exogenous. Yet, several factors may compromise such exogeneity. First, by definition, an individual's exposure to the RBM campaign depends on his or her age (i.e. the difference between DHS survey year and the individual's date of birth). As a consequence, a correlation exists between ($\text{exposure}_{ct} \times \text{PfPR}_{2000j}$) and ($\text{age}_{ct} \times \text{PfPR}_{2000j}$). Yet, ($\text{age}_{ct} \times \text{PfPR}_{2000j}$) is likely correlated with the dependent variable in Equation (3). The impact of pre-campaign malaria risk on educational outcomes may thus vary across age. To avoid this omitted variable bias, we include the interaction term ($\text{age}_{ct} \times \text{PfPR}_{2000j}$) in Equation (3).

Second, exposure to the RBM campaign may capture exposure to concomitant health and education initiatives. To absorb the impact of such programs, we introduce in Equation (3) an interaction term between the proportion of a child's life that has elapsed since the creation of the RBM in 1998[20] and PfPR_{2000j}.

Third, pre-campaign malaria risk is likely related to pre-campaign educational outcomes such that there is a correlation between ($\text{exposure}_{ct} \times \text{PfPR}_{2000j}$) and the interaction term between exposure_{ct} and pre-campaign educational outcomes at the cluster level. Yet, the

[20]This proportion is equal to 1 for a child born after 1998; it is equal to (DHS survey year-1998-1)/(DHS survey year-date of birth-1) for a child born before 1998.

latter interaction term is also plausibly correlated with the dependent variable in Equation (3): the impact of exposure to malaria control campaigns may vary depending on pre-campaign educational outcomes. Initially more (resp. less) educated individuals are indeed more (resp. less) likely to adopt anti-malaria strategies (see Nganda et al. (2004); Rhee et al. (2005); Hwang et al. (2010); Graves et al. (2011).[21] Unfortunately, due to data limitations, we cannot control for the interaction term between exposure_{ct} and pre-campaign educational outcomes at the cluster level. We control instead for the interaction term between exposure_{ct} and region fixed effects in Equation (3).[22]

Fourth, an individual's exposure to malaria control campaigns depends on his or her date of birth,[23] while pre-campaign malaria risk is correlated with local characteristics. Such correlations are a source of endogeneity if there are trends in educational outcomes at the local level, meaning that primary school students' born in different years and localities were initially exposed to different educational policies. To limit this endogeneity, we add an interaction term between students' date of birth and region fixed effects in Equation (3).[24]

Evidently, our additional controls cannot allow us to treat all sources of endogeneity in Equation (3). Our proxy for pre-campaign malaria risk, PfPR in the year 2000 in DHS cluster j, can be correlated to unobservables at the individual level within cluster j (like a household's readiness to adopt preventative strategies). It may also face attenuation bias due to measurement error (if this error is classical).

To address these concerns, we instrument pre-campaign malaria risk with six different sets of instrumental variables. These instruments must be such that they plausibly impact educational outcomes only through their impact on malaria risk. They should have no direct impact on educational outcomes, nor be correlated with any characteristics at the individual level within a given cluster that might be correlated with educational outcomes. As, we combine standard strategies with more novel instruments, we are hesitant to settle on a first-best strategy. For transparency, we present results for all six sets of instruments.

[21] See also Kenkel (1991) and Dupas (2011) for the relationship between education and health behavior.

[22] We obviously cannot control for the interaction term between exposure_{ct} and cluster fixed effects since this would drop the main variable of interest in our analysis, i.e. $(\text{exposure}_{ct} \times \text{PfPR}_{2000j})$.

[23] Indeed, everything else held constant, the later the date of birth, the higher the probability that the child was exposed to Global Fund's disbursements during his/her entire life.

[24] We focus on region rather than cluster fixed effects because educational policies are more likely to be determined at the region rather than cluster level in case they are (at least partly) decentralized. Regardless, an interaction term between cluster fixed effects and students' date of birth would drop the main variable of interest in our analysis, i.e. $(\text{exposure}_{ct} \times \text{PfPR}_{2000j})$.

These six sets encompass: latitude, longitude, and altitude at the cluster level (Set I), average temperature (annual mean temperature, maximum temperature of warmest month, minimum temperature of coldest month), annual precipitation, altitude and their polynomials (Sets II and III), frequency of G6PD deficiency and *P. falciparum* and basic reproductive number under control (PfRc) (Set IV), malaria ecology provided by MAP (i.e. probability of occurrence of Anopheles species that constitute dominant and secondary vectors of malaria in a given country in a given year) (Set V), as well Kiszewski et al. (2004)'s malaria stability index (Set VI).

Set I relies on geographic variables that have been strongly linked to malaria, that is, on the latitude, longitude and altitude at the cluster level. (See for instance Burlando (2012) for the use of altitude as an instrumental variable where higher altitudes are less malarious). Latitude and longitude are provided by DHS surveys. Altitude captures average elevation above sea level and is made available by the Shuttle Radar Topography Mission (SRTM).[25]

Sets II and III of instruments are similar to those used by Bleakley (2010) and Cutler et al. (2010) respectively. These instruments combine geographic and climatic variables. Bleakley (2010) instruments average malaria risk with average temperature and average altitude as well as the interaction of the two. We rely on the same instruments. Average temperature is the annual mean temperature provided by WorldClim[26] while average altitude is defined as in Set I. Cutler et al. (2010) use average temperature, average altitude, average humidity, average precipitation, and squared terms of all four variables as instruments. We rely on similar instruments and their squared terms: average temperature (annual mean temperature, maximum temperature of warmest month, minimum temperature of coldest month) as well as annual precipitation from WorldClim and average altitude from SRTM.

Set IV includes frequency of G6PD deficiency and the *P. falciparum* basic reproductive number under control (PfRc) at the DHS cluster level. We already described G6PD deficiency in Section 2.2. The PfRc is computed by MAP similarly by using information from the 1985-2010 period. The PfRc measures the potential for malaria to spread at the cluster level if the population in this cluster is naive (i.e. not yet affected by malaria) and endowed with its current level of malaria control (see Smith et al. (2007) and Gething et al. (2011).

[25]This database is available at `http://www2.jpl.nasa.gov/srtm/`.

[26]This database is available at `http://www.worldclim.org/` and is representative of the period 1950-2000.

The PfRc is a function of the human feeding rate, infectivity of mosquitoes to humans (and vice versa), death rate of mosquitoes, number of mosquitoes per human, number of days required for mosquito to complete sporogony, and expected waiting time to naturally clear a simple infection (Smith et al. (2007)). The MAP protocol modify this formula to account for heterogeneous biting behavior and existing control efforts. Therefore, by construction, PfRc correlates well to PfPR_{2000j}.

Sets V and VI use two different measures of malaria ecology that capture the geospatial stability of malaria transmission. We compute the first measure from the MAP database. Here, malaria ecology stands for the average, at the DHS cluster level, of the probability of occurrence of *Anopheles* species that constitute dominant and secondary vectors of malaria in a given country.[27] The second measure of malaria ecology is the stability index of Kiszewski et al. (2004). To generate a measure of malaria's transmission, the authors interact malaria vector behavior with climate characteristics. Several recent quasi-experimental studies rely this index as an instrument (see Bleakley (2010), Lucas (2010) and Venkataramani (2012)). While both indices are similar, MAP relies not only on environmental and climatic variables to estimate vector occurrence, but also uses vector-specific population models that predict how environmental and climatic factors impact the ecology and bionomics of each vector species. Furthermore, the MAP index is estimated at a much more disaggregated level, with grids of 1 km $\times$ 1 km resolution, while Kiszewski et al. (2004) rely on 55 km $\times$ 55 km grids (see Sinka et al. (2010) and Sinka et al. (2012)). This offers higher precision and greater cross-cluster variation.

3.3 Testing the parallel trend assumption

For coefficient β in Equation (3) to capture the causal impact of the RBM campaign on educational achievements, it should *not* be the case that, prior to the RBM campaign, health and educational outcomes of individuals in the treatment group (i.e. those living in regions with higher pre-campaign malaria risk) already converge to those of individuals in the

[27] This approach for computing the ecology measure implies that different species must be taken into account for each of our 14 countries: *funestus*, *nili*, *gambiae*, *arabiensis* for Burkina Faso, Malawi, Mali and Namibia; *funestus*, *nili*, *gambiae*, *arabiensis*, *moucheti* for Rwanda and Uganda; *funestus*, *nili*, *gambiae*, *arabiensis*, *melas*, *moucheti* for Cameroon and Nigeria; *funestus*, *nili*, *arabiensis* for Ethiopia; *funestus*, *nili*, *gambiae*, *arabiensis*, *melas* for Ghana, Guinea and Senegal; *funestus*, *nili*, *gambiae*, *arabiensis*, *moucheti*, *merus* for Kenya; *funestus*, *nili*, *gambiae*, *arabiensis*, *merus* for Zimbabwe.

control group (i.e. those living in regions with lower pre-campaign malaria risk). Were such catch-up effects at work prior to the campaign, we would not be able to disentangle whether β measures the impact of the RBM campaign or merely the pursuit of this pre-campaign trend.

To rule out the possibility of a pre-campaign catch-up effect, we perform a falsification test. We estimate Equation (3) among individuals who had already left primary school when RBM's campaign began. More precisely, we define these individuals as those whose age is above the maximum age among our primary school students when the campaign started (this maximum age varies between 24 and 25). Measures of their health and educational outcomes before the RBM campaign should therefore not be impacted by the campaign. More precisely, finding a positive and significant β would suggest that catch-up effects between the treatment and the control group were already at stake prior to the campaign.

We focus on two dependent variables. The first one is the weight-for-height percent of reference median based on WHO reference standard for adult females. We use it as a proxy for health conditions during the childhood of those adults who belong to our sample. The second dependent variable is the years of education these adults completed when they were enrolled at primary school.

Tables 4 and 5 provide OLS and IV estimates, respectively. As expected, coefficient β is never robustly positive, except in Cameroon. Therefore, the results we obtain when we estimate Equation (3) among primary school students in Cameroon will need to be taken with caution since pre-campaign catch-up effects seem to be at work in this country.

4 Results

In this section, we first present OLS estimates of Equation (3). We then provide our 2-SLS results. We conclude by performing robustness checks.

4.1 OLS estimates

As described in Section 2.3, there are several channels through which malaria control can improve student's educational attainment. However, by reducing the mortality of children under the age of five, anti-malaria campaigns can also impose considerable strain on educa-

tional resources if enrollment increases substantially. Moreover, if weaker students are more likely to enroll thanks to malaria control programs, these students may also more likely to fall behind. Thus, the impact of malaria control on schoolchildren's educational attainment is ambiguous ex-ante.

We present descriptive statistics of our main primary school student population in Table 6. Tables 7 through 9 present OLS estimates of coefficient β in Equation (3) where the dependent variables are grade, years, and delay.[28] Controls are added sequentially into Equation (3): individual covariates (gender, age and wealth, and year of birth, DHS cluster as well as DHS survey year fixed effects (column 1); the interaction term between regional fixed effects and exposure (column 2); the interaction term between pre-campaign malaria risk and student's age (column 3); the interaction term between regional fixed effects and student's date of birth (column 4); and the interaction between the 1998 time trend and pre-campaign malaria risk (column 5). In a majority of countries (13 of 14), malaria control leads to statistically significant increases in grade and years and/or statistically significant reductions in schooling delay (Cameroon is this exception). We now turn to an IV approach to address the issues outlined in Section 3.2.

4.2 IV estimates

For a specific set of instruments, the first-stage of the 2SLS consists of regressing the interaction term between exposure to RBM disbursements and PfPR in 2000 on interaction terms composed of exposure and each of the instruments that belong to this set. Naturally, all controls present in the second stage are also present in the first stage.

We provide results of an OLS estimation which regresses PfPR in 2000 on the various sets of instrumental variables in Section S1 of the supplemental appendix. Tables S1-1 to S1-14 reveal highly significant correlations between pre-campaign malaria risk and all three sets of instruments. Moreover, Section S1 displays F-statistics that are, with rare exceptions, greater than 10.

Results from the second stage of the 2-SLS approach, which relies on Equation (3), are

[28] Our objective is to measure the average marginal impact of exposure to the RBM anti-malaria campaigns, that is the impact of exposure to RBM when explanatory variables in Equation (3) are set at their average. When "delay" is the dependent variable, an OLS approach amounts to estimating a linear probability model which provides similar marginal effects as would a probit or a logit analysis (see Angrist (2001)).

reported in Tables 10 through 12. We also report the Durbin-Wu-Hausman (DWH) χ^2 test for each country. For the majority of cases, this test rejects the null hypothesis according to which OLS and IV estimates are not significantly different from each other.

Figure 6 helps us to visualize our findings. For all countries, we display OLS results. Plus and minus signs indicate the sign of coefficient β in Equation (3). A cell is highlighted in grey if the coefficient is statistically significant and left blank otherwise. For each country, we include the IV results only if the DWH test is rejected in at least 4 of the 6 IV sets. We apply the same majority selection rule (4/6) to report both the sign and the significance in each IV cell.

The DWH test indicates that the IV results must be trusted for at least one of our three dependent variables, in each country of our sample. We conclude that, with the exception of Guinea where the impact of the RBM campaign is not statistically significant based on the 2-SLS estimates, the RBM campaign leads to significant increases in grade level and years of schooling (9 countries) and/or reductions in schooling delay (13 countries). It is worth emphasizing that the orders of magnitude are greater with the IV than with the OLS approach. This indicates that our OLS estimates are possibly subject to an underestimation bias, which is consistent with the various sources of endogeneity previously highlighted.

4.3 Robustness checks

4.3.1 Ruling out a migration effect

The variable PfPR_{2000j} in Equation (3) captures pre-campaign malaria risk in the DHS cluster where the respondent currently lives. There is no guarantee that this place of residence coincides with the respondent's place of birth (this information is absent from the DHS surveys, as is the respondent's migrant status).

Yet, it is unlikely that migration of primary schoolchildren from non-malarious to malarious regions drives our results. Focusing on a youth population limits the time window available for migration. Moreover, our results are consistent across countries that show different internal migration rates. For instance, we find a positive impact of the Global Fund's anti-malaria campaigns on educational attainment in Ghana, Kenya, Mali, Rwanda, Sene-

gal, Uganda and Zimbabwe, although lifetime crude internal migration intensity[29] varies substantially across these countries, from 10.4% in Rwanda to 28.9% in Zimbabwe (see United Nations (2013)). Evidence further suggests that individuals prefer migrating to non-malarious rather than to malarious regions (see Sachs and Malaney (2002) and Hong (2011)). Notably, Sawyer (1993) shows that malarious regions in Brazil deter permanent migration. If anything, they attract male temporary workers who do not migrate with their family. Note that one might still worry about a selection bias whereby individuals (parents) with higher levels of education will likely choose to live in areas that are the least conducive to malaria risk and parents' education is strongly correlated to their children's education. Controlling for the household's wealth in Equation (3) helps us to proxy for parental education and mitigate concerns about this selection bias.

Nevertheless, we replicate Equation (3) by restricting our analysis to heads of household who report themselves to be permanent residents of their current location. This is an imperfect test because this information is not available for many countries and DHS rounds. To proceed, we must confine our analysis to Ghana, Kenya, Malawi, Mali, Namibia, and Nigeria. OLS results, reported in Table S2-1, hold for all countries. IV results, reported in Tables S2-2 to S2-4, hold for all countries except Kenya: in this country, coefficient β is statistically significant (with the correct sign) for only one or two sets of IVs.

4.3.2 Relying on an alternative measure of pre-campaign malaria risk

We use an alternative measure for pre-campaign malaria risk. This measure comes from the Mapping Malaria Risk in Africa/Atlas du Risque de la Malaria en Afrique (MARA/ARMA) data. It represents the percentage of the population living in holo- and hyper-endemic areas during the year prior to the start of the Global Fund's disbursements in the regions of a subsample (7) of our 14 countries.

Table S3-1 in the supplemental appendix present OLS estimates of coefficient β in Equation (3) when our PfPR measure is replaced by the MARA/ARMA measure (computed at the regional level). OLS results hold for all countries except Senegal (and improve for Cameroon). Tables S3-2 to S3-4 of the supplemental appendix present IV estimates. Over the seven countries for which MARA/ARMA data are available, our IV results hold for all

[29] Crude internal migration is the proportion of internal migrants across regions in a country's population.

countries (and improve for Guinea).

5 Discussion

5.1 Educational cost-effectiveness

Our results reveal that, in 13 countries, the RBM malaria control campaigns positively affect schooling attainment (in terms of years and grade level) and/or negatively affect delay. In order to discuss the educational cost effectiveness of promoting school participation through RBM rather than through alternative educational interventions, we provide the cost of an additional year of school participation.

Let us consider Kenya, where the average primary student is 11.40 years-old in our dataset and lives in an area impacted by *P. falciparum* malaria. If RBM introduced a yearly per capita investment of $1 over the first 12.40 years of this student's lifetime (taking in-utero exposure into account), he/she would benefit from 2.93 additional years of schooling.[30] Put differently, RBM-sponsored interventions of this kind increased school participation by approximately 2.93 years for this student. The proportion of children enrolled in Kenya was approximately 26.60% of the total population in 2000. Assuming that this figure is roughly stable over the student's lifetime, the cost of one additional year of school induced by RBM is thus $ 15.90 (=12.40/[2.93 x 0.266]).

Estimates for our 14 countries are provided in Figure 7.[31] The average cost per extra year of school participation induced by the RBM is $ 13.19. Figure 7 adds the Abdul Latif Jameel Poverty Action Lab's (2005) summary of the cost-effectiveness of various programs in increasing school participation (as reviewed by Kremer and Holla (2009)). We can thus compare where our cost-effectiveness estimates fall within a wide range of other educational interventions. For instance, Miguel and Kremer (2004) found that it costs approximately $3.50 per additional year of school participation induced by a school-based mass treatment

[30] To get this order of magnitude, we first compute the average of coefficients β of Equation (3) for all the IV strategies where these coefficients are statistically significant (see Table 11). This average is equal to 16.786. We then multiply this figure by the mean value of PfPR in 2000 which is equal to 0.175.

[31] Figure 7 is virtually unchanged when we rely on the proportion of children enrolled in primary school over the 2000-2010 period rather than in 2000. We also note that, in our sample, the gross enrollment rate is increasing by 13% on average between 2000 and 2010, which implies that our cost estimate, which focuses on enrollment in 2000, is an upper bound.

with deworming drugs. Five countries are below this threshold of $3.50 per additional year of schooling attainment and 9 countries are above. Large-scale campaigns like RBM are likely less efficient at increasing attainment compared to carefully controlled experiments, all the more given that the most targeted populations are not school-age children. However, in all countries, the RBM shows a lower cost than school uniforms or merit scholarship programs in Kenya (Kremer, 2003; Kremer and Holla, 2009; Kremer, Miguel and Thornton, 2009). Thus, even when compared to other educational interventions, RBM is a cost-effective method of increasing years of schooling.

5.2 Heterogeneous effects

To the extent that RBM improves schooling, it is important to consider precisely who reaps the benefits, with special consideration given to traditionally marginalized groups. For example, if attainment increases for the relatively poorer segments of the population, RBM spillovers contribute to a more equitable educational environment. Moreover, the RBM campaigns may affect girls differentially to boys. Gender norms can influence malaria exposure depending on who is more likely to be working in the fields at dusk or gathering water early in the morning. Similarly, norms around decision-making and sleeping arrangements may influence how households seek health care or determine who sleeps under mosquito nets. Though we are not able to examine these questions in detail, we can observe whether our schooling outcomes differ by gender.

In order to study heterogeneous effects, we introduce in Equation (3) an interaction term to capture effects on enrollment for two groups: the relative poor and girls. More precisely, we interact ($\text{exposure}_{ct} \times \text{PfPR}_{2000j}$) with an indicator that is equal to one if a respondent is in the two poorest wealth quintiles (and zero otherwise) or an indicator for female. (Results are available upon request.) Regarding underprivileged students, most countries exhibit no differential treatment effects on attainment. Only in Nigeria and Rwanda do underprivileged students benefit significantly less from RBM. If we turn our attention to gender imbalances, it is notable that the enrollment and attainment gender gap was closing rapidly by 2000 (Schultz, 1999).[32] Our descriptive statistics show no particular difference between boys and

[32]This catch-up can be attributed in large part to the increasing returns to educating females for occupations in agriculture and trade, rather than to improvements in health.

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girls for our variables of interest at baseline. Moreover, our test for heterogeneous treatment effects by gender does not show a significant difference between boys and girls, though our IV coefficients tend to be more frequently negative for females.

Finally, we note that by reducing mortality and increasing returns to education, large health campaigns can also spur enrollment. By estimating Equation (3) on the probability for an individual of primary school age to be enrolled in primary school, we can provide some suggestive evidence on changes to the student body with respect to RBM. Moreover, because less privileged children typically perform worse in school (Glewwe, Kremer and Moulin, 2009), the campaign's effects on attainment may constitute a lower bound if a greater number of such students are enrolling in school. In all countries except Senegal, exposure to the RBM increases a student's probability of enrollment. (Results are available upon request.) When we introduce indicators for wealth and gender, differential effects emerge. In 7 countries (Guinea, Malawi, Mali, Nigeria, Rwanda, Senegal, and Zimbabwe) poorer students are less likely to enroll relative to wealthier students, and in 8 countries (Cameroon, Kenya, Malawi, Mali, Rwanda, Senegal, Uganda and Zimbabwe) girls are less likely to enroll relative to boys. Thus, in these countries, traditionally marginalized groups are less likely to enroll thanks to RBM but, once they are enrolled, differences in attainment virtually disappear.

6 Conclusion

We document the effects of the RBM malaria control campaigns on primary school attainment in Sub-Saharan Africa using microeconomic data from 14 countries. Consistent with other geographically-specific studies analyzing the effects of large-scale health interventions and policies, we find a positive impact on education (Jayachandran and Lleras-Muney, 2009; Bleakley, 2010; Cutler et al., 2010; Lucas, 2010; Venkataramani, 2012). We show that school-age children, 26% of the population in Africa,[33] strongly benefit in terms of higher grade levels and/or reduced delays in primary school progression. Moreover, at $ 13.19 per each additional year of schooling on average, RBM appears to be highly cost-effective on relative to standard educational interventions (Kremer, 2003; Miguel and Kremer, 2004; Kremer and

[33]This figure comes from 2013 UN Population Division data.

Holla, 2009; Kremer, Miguel and Thornton, 2009).

Our findings point to the importance of considering educational outcomes in addition to health when investing in and evaluating large-scale health interventions. Mass interventions can help to break inter-generational health-based poverty traps in which poor early childhood health impedes school participation and performance, lowers labor participation and earnings, and increases the need for health care.

Documenting spillover effects of such interventions is not a trivial exercise given the difficulty in estimating the medium-term effectiveness of programs aiming to *reduce* but not eliminate health challenges (Miguel and Kremer, 2004; Ashraf, Fink and Weil, 2014). Certainly the educational benefits from malaria intervention will never be large enough to compete for attention with the direct health benefits (Jamison et al., 2013), but they may be able to compete with standard educational programs.

Our results do face some limitations. While we provide evidence that our effects may be persistent, a more general analysis of the long-run, general equilibrium impacts induced by RBM is left for further investigation. For example, population increases thanks to health interventions may put pressure on social service provision. Similarly, how the labor market reacts to rightward shifts in human capital has important implications for economic productivity and growth. Therefore, observing the net effect of the RBM on GDP per capita will take time to come to fruition, and our understanding is limited to the transitory phase.

Nonetheless, we believe our analysis can inform the debate on the impact of exogenous, large-scale health shocks in developing countries. Some question if policy-makers can promote education and economic development via public healthcare interventions (see Acemoglu and Johnson (2007, 2014) for a discussion). We provide evidence that, at least in the case of malaria control efforts, improving education is a reality.

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7 Figures & tables

Figure 1: DHS survey rounds, RBM campaign's start date and average yearly per capita disbursements

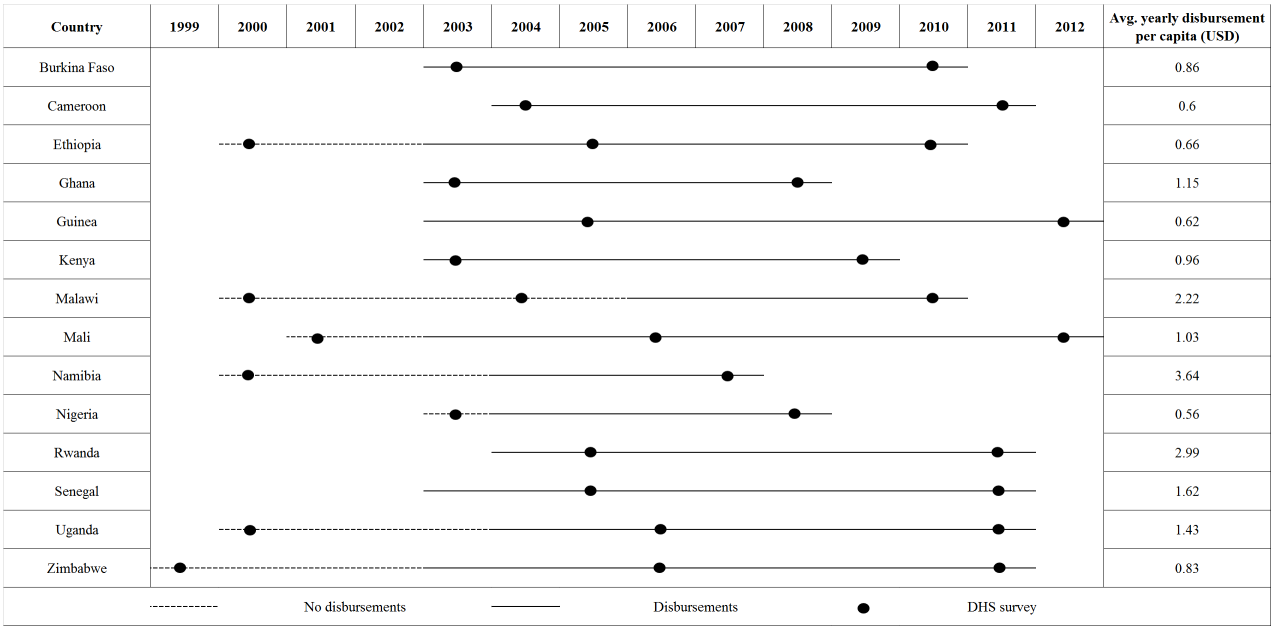
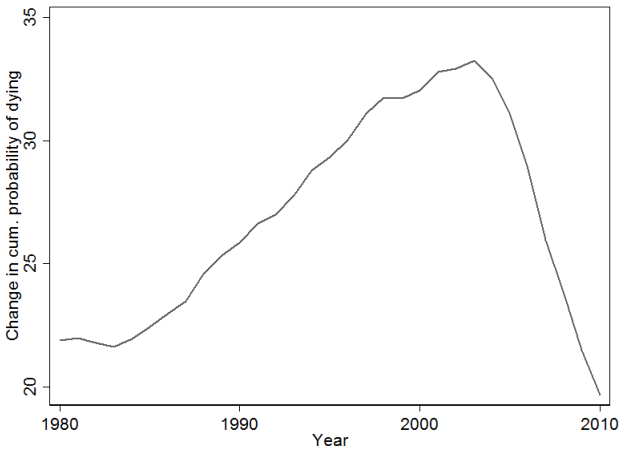
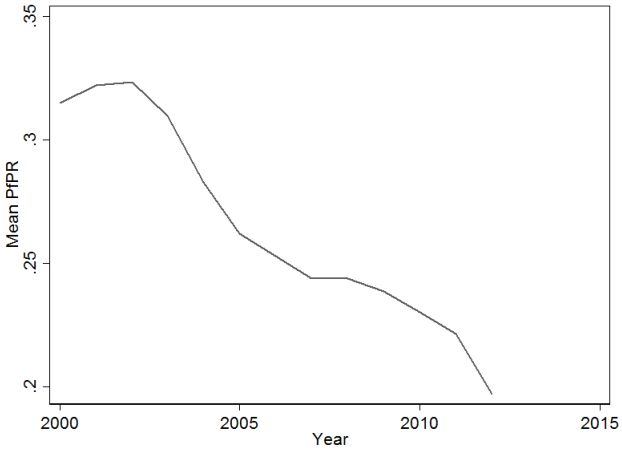


Figure 2: Cumulative probability of dying from malaria for children under five over all Sub-Saharan countries



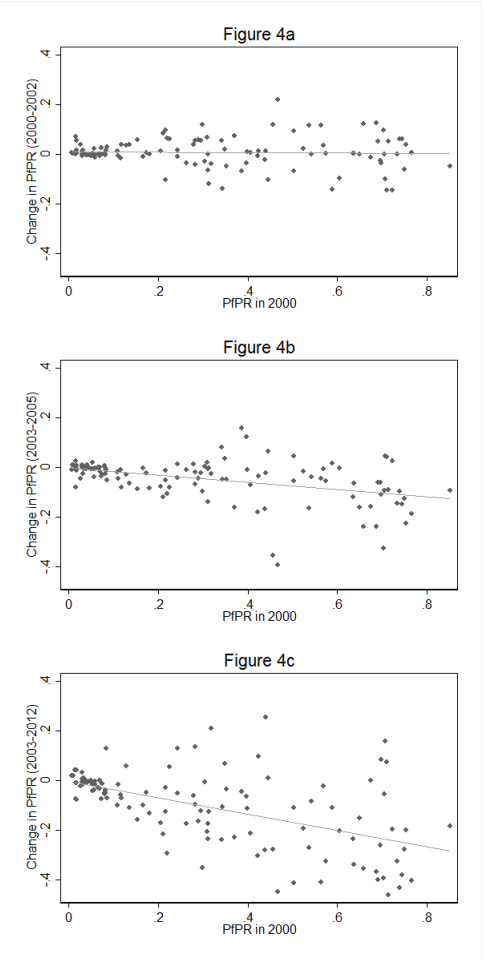
Note: We obtain data on the cumulative probability of dying from malaria (for children under five) from Institute for Health Metrics and Evaluation (IHME).

Figure 3: Evolution of PfPR (*Plasmodium falciparum* parasite rate) in our sample



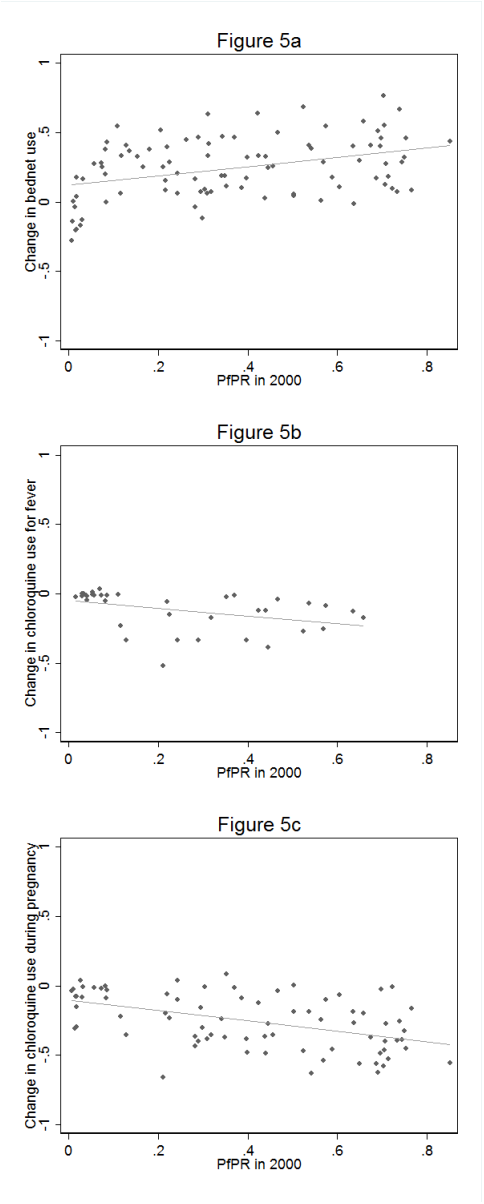
Note: The line plots the mean PfPR taken over all 14 countries from our DHS sample against time. We obtain yearly PfPR from the Malaria Atlas Project. In a regression of the change in PfPR between 2000 and 2002 on a constant, the coefficient on the constant is 0.008 and is not statistically significant ($N = 120$). For the change in PfPR between 2003 and 2005, the coefficient on the constant is -0.047 and is statistically significant at 0.1% ($N = 120$). For the change in PfPR between 2003 and 2012, the coefficient on the constant is -0.104 and is statistically significant at 0.1% ($N = 120$). Note that the turning point is also similar to Figure 1.

Figures 4a-4c: Evolution of PfPR at the regional level conditional on initial PfPR



Note: Each point represents a DHS region. We obtain yearly PfPR from the Malaria Atlas Project. In a univariate regression of the change in PfPR between 2000 and 2002 on the initial PfPR in 2000, the coefficient on initial PfPR is -0.014 and is not statistically significant (Figure 4a, $N = 120$). For the change in PfPR between 2003 and 2005, the coefficient on initial PfPR is -0.140 and is statistically significant at 0.1% (Figure 4b, $N = 120$). For the change in PfPR between 2003 and 2012, the coefficient on initial PfPR is -0.318 and is statistically significant at 0.1% (Figure 4c, $N = 120$).

Figures 5a-5c: Evolution of bednet and chloroquine use over time conditional on initial PfPR



Note: Each point represents a DHS region. We obtain yearly PfPR from the Malaria Atlas Project. In a univariate regression of the change in bednet use between the most recent and earliest surveys on initial PfPR in 2000, the coefficient on initial PfPR is 0.312 and is statistically significant at the 0.1% level (Figure 5a, $N = 93$). For the change in chloroquine use, the coefficient on initial PfPR is -0.279 and is statistically significant at the 0.1% level (Figure 5b, $N = 37$). For the change in chloroquine use during pregnancy, the coefficient on initial PfPR is -0.373 and is statistically significant at the 0.1% level (Figure 5c, $N = 77$).

Figure 6: Summary of results

Country	OLS			IV		
	Grade	Years	Delay	Grade	Years	Delay
Burkina Faso	+	+	-	+	+	-
Cameroon	+	+	+	+	+	-
Ethiopia	+	+	-	+	+	-
Ghana	+	+	-	+	+	-
Guinea	+	+	-	+	+	-
Kenya	+	+	-	+	+	-
Malawi	+	-	-	+	+	-
Mali	+	+	-	+	+	-
Namibia	+	+	-	+	+	-
Nigeria	+	+	-	+	+	-
Rwanda	+	+	-			-
Senegal	+	+	-	+	+	-
Uganda	+	+	-			-
Zimbabwe	+	+	-	+	+	-

Note: Plus and minus signs indicate the sign of coefficient β in Equation (3). A cell is highlighted in grey if the coefficient is statistically significant and left blank otherwise. For each country, we include the IV results only if the DWH test is rejected in at least 4 of the 6 IV sets. We apply the same majority selection rule (4/6) to report both the sign and the significance in each IV cell. Burkina Faso, Cameroon, Ethiopia, Ghana, Mali, Namibia, Nigeria, Senegal, and Zimbabwe are valid in 6/6 or 5/6 for all dependent variables. Malawi, Rwanda, and Uganda are valid in 6/6 or 5/6 for delay only. Finally, Guinea is borderline for all dependent variables with 3/6 valid estimations.

Figure 7: Educational cost-effectiveness (cost of an additional year of schooling)

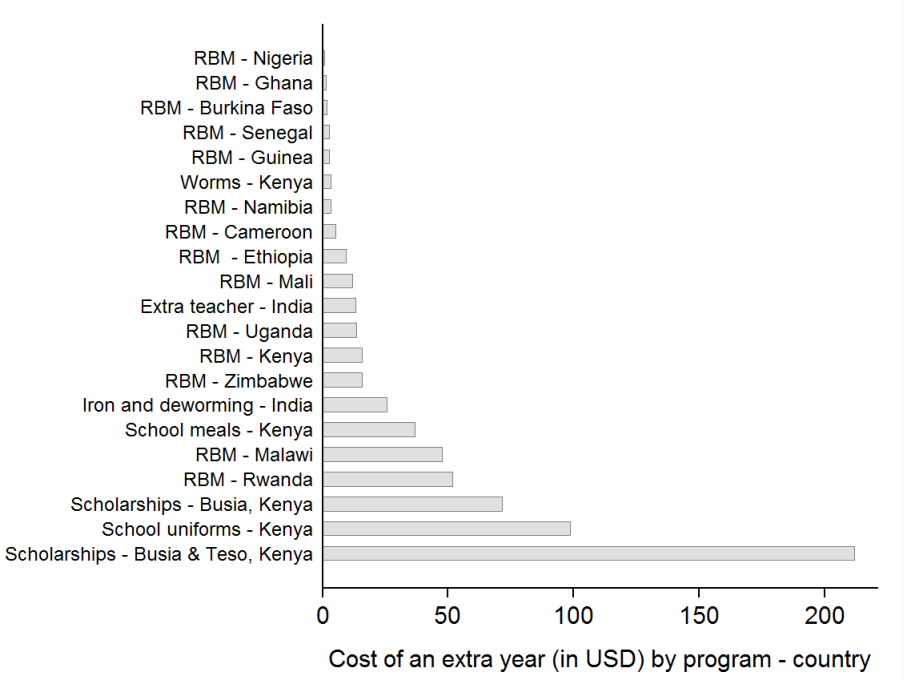


Table 1: Impact of malaria on health and education

	Fever	Fever	Dead	Dead	Grade	Grade	Years	Years	Delay	Delay
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
PfPR*G6PD*Rainy	0.097*		0.065***							
	(0.034)		(0.015)							
Lag PfPR*G6PD*Rainy		0.096*		0.103***						
		(0.037)		(0.014)						
PfPR*G6PD					-0.175*		-0.157*		0.091***	
					(0.074)		(0.077)		(0.018)	
Lag PfPR*G6PD						-0.033		-0.213*		0.064***
						(0.074)		(0.077)		(0.018)
Region FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year of birth FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Survey year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Individual covariates	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
R^2	0.071	0.071	0.503	0.504	0.601	0.601	0.603	0.603	0.434	0.434
Observations	263,340	263,340	308,537	308,537	336,691	336,691	336,627	336,627	336,691	336,691

Notes: Each cell reports the coefficient of interest Equation (1). The unit of observation is the individual. Estimates include fixed effects for region, year of birth, and survey year and individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ^, *, ** and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 2: Impact of malaria on health and education depending on initial level of malaria risk (in 2000)

	Fever	Dead	Grade	Years	Delay
	(1)	(2)	(3)	(4)	(5)
PfPR*Time*Rainy	-0.140*	-0.063***			
	(0.048)	(0.015)			
PfPR*Time			0.201*	0.228*	-0.036*
			(0.071)	(0.073)	(0.017)
Region FE	yes	yes	yes	yes	yes
Year of birth FE	yes	yes	yes	yes	yes
Region * Survey year FE	yes	yes	yes	yes	yes
Individual covariates	yes	yes	yes	yes	yes
R^2	0.075	0.497	0.607	0.609	0.443
Observations	220,342	258,926	281,866	281,819	281,866

Notes: Each cell reports the coefficient of interest from Equation (2). The unit of observation is the individual. Estimates include fixed effects for region, year of birth, and region-by-survey year and individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ˆ, *, ** and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 3: Impact of malaria on fertility

	Ideal	Ideal	Live births	Live births	Alive	Alive	Ideal	Live births	Alive
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PfPR*G6PD	0.070*		0.014		-0.008				
	(0.024)		(0.025)		(0.023)				
Lag PfPR*G6PD		0.120***		0.017		-0.003			
		(0.027)		(0.025)		(0.023)			
PfPR*Time							-0.034ˆ	-0.015	0.025
							(0.020)	(0.023)	(0.021)
Region FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year of birth FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Survey year FE	yes	yes	yes	yes	yes	yes	no	no	no
Region * Survey year FE	no	no	no	no	no	no	yes	yes	yes
Individual covariates	yes	yes	yes	yes	yes	yes	yes	yes	yes
R^2	0.261	0.261	0.631	0.631	0.582	0.582	0.287	0.633	0.585
Observations	342,343	342,343	371,438	371,438	371,438	371,438	287,638	313,507	313,507

Notes: Each cell reports the coefficient of interest from Equation (2) (columns 1-6) and Equation (1) (columns 5-10). The unit of observation is an adult woman. The dependent variables are the logarithm of one plus the ideal number of children, the total number of live births, and the number of children alive, respectively. Estimates in columns 1 to 6 include fixed effects for region, year of birth, and survey year and individual covariates (age, gender, wealth). Estimates in columns 7 to 9 include fixed effects for region, year of birth, and region-by-survey year and individual covariates. Standard errors (in parentheses) are clustered at the DHS cluster level. Standard errors (in parentheses) are clustered at the DHS cluster level. ˆ, *, ** and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 4: Testing the parallel trend assumption: OLS estimates for female weight-for-height and adult years of education completed

	Weight-for-height	Years of education completed		Weight-for-height	Years of education completed
	(1)	(2)		(3)	(4)
Burkina Faso	-1.89e+04	-16.313ˆ	**Mali**	43664.925	-12.900*
	(38519.934)	(9.776)		(29619.143)	(3.963)
R^2	0.345	0.363	R^2	0.283	0.323
Observations	9,678	39,573	Observations	15,892	59,021
Cameroon	4565.781	54.718***	**Namibia**	-2.86e+05	-99.140
	(52394.059)	(9.489)		(5.62e+05)	(97.951)
R^2	0.409	0.623	R^2	0.289	0.419
Observations	5,153	36,199	Observations	4,532	28,325
Ethiopia	-4.90e+04	0.730	**Nigeria**	-5.77e+04	-19.786
	(1.12e+05)	(59.424)		(71485.899)	(24.306)
R^2	0.323	0.524	R^2	0.245	0.564
Observations	17,504	66,223	Observations	18,266	60,201
Ghana	20862.549	-50.681***	**Rwanda**	7716.871	5.930
	(77824.974)	(15.346)		(21558.089)	(4.971)
R^2	0.404	0.524	R^2	0.307	0.336
Observations	5,095	24,289	Observations	5080	27993
Guinea	27431.176	7.258	**Senegal**	-6.32e+04	-14.115ˆ
	(71106.720)	(11.306)		(54636.733)	(7.779)
R^2	0.330	0.328	R^2	0.335	0.386
Observations	3,538	24,237	Observations	3,764	38,760
Kenya	-7.65e+04	-25.170	**Uganda**	-5.95e+04ˆ	1.889
	(59388.463)	(17.274)		(31472.723)	(6.807)
R^2	0.357	0.581	R^2	0.375	0.444
Observations	7,090	23,189	Observations	5,959	31,268
Malawi	-1.08e+04	-6.040*	**Zimbabwe**	-1.18e+05	-70.600
	(8649.222)	(3.015)		(2.63e+05)	(108.224)
R^2	0.189	0.404	R^2	0.242	0.475
Observations	19,835	79,814	Observations	10,070	34,349

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is an adult woman (column 1) and an adult (column 2). All estimates include fixed effects for cohort, cluster, and survey year as well as exposure-by-region, age-by-PfPR, cohort-by-region, exposure since 1998-by-PfPR, and individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ˆ, *, ** and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 5: Testing the parallel trend assumption: IV estimates for female weight/height and adult years of education completed

	Weight/height						Years of education completed					
	Set I	Set II	Set III	Set IV	Set V	Set VI	Set I	Set II	Set III	Set IV	Set V	Set VI
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Burkina Faso	-4177.799	15744.877	16214.081	-3.45e+04	27949.440	22872.301	-25.302	-36.371*	-27.837^	-94.001***	-30.755^	-18.620
	(53861.254)	(53256.653)	(50726.628)	(54908.077)	(53247.291)	(54301.550)	(15.808)	(15.435)	(14.904)	(17.324)	(15.803)	(15.543)
R^2	0.345	0.345	0.345	0.345	0.345	0.345	0.363	0.363	0.363	0.361	0.363	0.363
Observations	9,678	9,678	9,678	9,678	9,678	9,678	39,573	39,573	39,573	39,573	39,573	39,573
Cameroon	2.01e+05*	1.34e+05	1.25e+05	30776.102	98967.658	-5.74e+04	59.640*	65.558***	49.734*	68.688***	65.061*	57.092*
	(93679.346)	(88485.474)	(82931.948)	(89697.195)	(1.11e+05)	(1.69e+05)	(18.763)	(18.280)	(17.018)	(19.244)	(20.461)	(26.216)
R^2	0.407	0.408	0.408	0.409	0.409	0.409	0.623	0.623	0.623	0.623	0.623	0.623
Observations	5,144	5,144	5,144	5,147	5,153	5,153	36,134	36,134	36,134	36,153	36,199	36,199
Ethiopia	6.98e+05*	5.66e+05*	3.46e+05^	4.32e+05^	6.54e+05*	0.000	75.330	82.830	26.239	126.501	172.542	0.000
	(2.53e+05)	(2.35e+05)	(1.77e+05)	(2.21e+05)	(2.82e+05)	(1.92e+05)	(134.810)	(128.591)	(99.728)	(126.217)	(158.930)	(99.757)
R^2	0.321	0.321	0.322	0.289	0.321	0.323	0.524	0.524	0.524	0.470	0.524	0.524
Observations	17,504	17,504	17,504	14,179	17,504	17,504	66,223	66,223	66,223	53,681	66,223	66,223
Ghana	2926.190	5428.436	-5244.998	69235.820	-1.08e+04	7953.570	-61.619*	-64.799*	-63.115*	-85.086***	-58.967^	-82.312*
	(1.48e+05)	(1.51e+05)	(1.33e+05)	(1.52e+05)	(1.67e+05)	(1.52e+05)	(23.750)	(23.681)	(22.384)	(24.653)	(34.432)	(30.433)
R^2	0.404	0.404	0.404	0.404	0.404	0.404	0.523	0.523	0.523	0.523	0.524	0.524
Observations	5,071	5,071	5,071	5,088	5,095	5,095	24,165	24,165	24,165	24,267	24,289	24,289
Guinea	-5814.965	-1.11e+04	-3.51e+04	-1.54e+05	-4.28e+04	84882.017	40.199*	31.976^	36.172*	25.482	22.176	15.001
	(1.19e+05)	(1.18e+05)	(1.13e+05)	(1.36e+05)	(1.30e+05)	(1.56e+05)	(18.657)	(18.029)	(17.906)	(21.657)	(26.790)	(32.988)
R^2	0.330	0.330	0.330	0.326	0.330	0.330	0.325	0.326	0.326	0.324	0.328	0.328
Observations	3,497	3,497	3,497	3,525	3,538	3,538	24,010	24,010	24,010	24,157	24,237	24,237
Kenya	2.64e+05	3.73e+05	34997.254	-8.25e+04	2.53e+05	0.000	-364.365*	-373.019*	-116.651^	31.972	26.360	-615.262
	(3.77e+05)	(3.86e+05)	(2.83e+05)	(2.93e+05)	(4.37e+05)	(2.38e+05)	(131.950)	(134.104)	(65.865)	(67.071)	(144.200)	(868.119)
R^2	0.355	0.353	0.358	0.359	0.354	0.357	0.570	0.570	0.581	0.574	0.581	0.546
Observations	7,049	7,049	7,049	5,563	7,090	7,090	23,056	23,056	23,056	18,116	23,189	23,189
Malawi	-1.93e+04	-1.82e+04	-1.21e+04	-7931.348	-1.71e+04	-1.17e+04	1.858	1.110	-6.026	0.604	-3.528	-10.728
	(13628.887)	(13447.776)	(11106.896)	(12721.689)	(13697.057)	(15713.317)	(5.119)	(5.001)	(4.172)	(5.065)	(5.380)	(6.949)

R^2	0.189	0.189	0.189	0.189	0.189	0.189	0.404	0.404	0.404	0.404	0.404	0.404
Observations	19,835	19,835	19,835	19,835	19,835	19,835	79,814	79,814	79,814	79,814	79,814	79,814
Mali	1.07e+05*	95768.868ˆ	64346.482ˆ	44190.500	73445.468	76345.130	-19.011*	-18.147*	-13.872ˆ	-18.445*	-17.635*	-20.422*
	(52984.524)	(53719.478)	(39078.896)	(34154.023)	(52787.494)	(57137.179)	(9.244)	(9.250)	(7.453)	(6.140)	(8.899)	(10.101)
R^2	0.282	0.283	0.283	0.281	0.283	0.283	0.323	0.323	0.323	0.323	0.323	0.323
Observations	15,892	15,892	15,892	15,648	15,892	15,892	59,021	59,021	59,021	58,248	59,021	59,021
Namibia	-8.62e+05	-6.38e+05	-6.37e+05	0.000	0.000	0.000	-318.663*	-261.122ˆ	-261.660ˆ	-304.009ˆ	-337.588*	-487.958*
	(9.60e+05)	(9.55e+05)	(9.25e+05)	(2.59e+05)	(2.84e+05)	(2.84e+05)	(148.736)	(147.091)	(141.853)	(163.204)	(171.241)	(213.771)
R^2	0.290	0.290	0.290	0.284	0.289	0.289	0.416	0.416	0.416	0.417	0.419	0.418
Observations	4,502	4,502	4,502	2,892	4,532	4,532	27,836	27,836	27,836	16,461	28,325	28,325
Nigeria	40713.450	-8.86e+04	-1.47e+05	-6.34e+05*	-2.02e+05	1.85e+05	14.087	-12.756	-3.846	110.009	7.138	-52.698
	(1.71e+05)	(1.52e+05)	(1.45e+05)	(2.21e+05)	(1.70e+05)	(2.49e+05)	(59.403)	(48.955)	(45.162)	(67.829)	(50.860)	(64.195)
R^2	0.244	0.245	0.245	0.242	0.244	0.244	0.564	0.564	0.564	0.563	0.564	0.564
Observations	18,266	18,266	18,266	18,266	18,266	18,266	60,201	60,201	60,201	60,201	60,201	60,201
Rwanda	82635.477	81549.251	48769.811	59207.342	86788.963	1.63e+05	-6.706	-7.149	1.848	-10.583	-5.909	20.756
	(50388.987)	(51687.037)	(45248.697)	(47397.604)	(62827.360)	(1.27e+05)	(8.545)	(8.632)	(7.399)	(8.387)	(11.941)	(41.162)
R^2	0.304	0.304	0.306	0.313	0.303	0.292	0.336	0.336	0.336	0.333	0.336	0.336
Observations	5,080	5,080	5,080	4,092	5,080	5,080	27,993	27,993	27,993	22,427	27,993	27,993
Senegal	71482.807	69111.334	15878.358	60413.445	-7.18e+04	38386.154	-68.243*	-71.467*	-74.010***	-74.138*	-77.534*	-107.993*
	(1.39e+05)	(1.38e+05)	(1.20e+05)	(1.37e+05)	(1.46e+05)	(1.74e+05)	(26.930)	(26.815)	(20.762)	(25.052)	(25.876)	(36.486)
R^2	0.330	0.331	0.331	0.333	0.335	0.334	0.385	0.385	0.385	0.384	0.384	0.381
Observations	3,724	3,724	3,724	3,764	3,764	3,764	38,457	38,457	38,457	38,760	38,760	38,760
Uganda	-1.19e+05ˆ	-6.85e+04	-1.12e+05*	-1.67e+04	-4.86e+04	-1.69e+05*	-33.413*	-15.326	-14.506	-28.686ˆ	-4.840	-42.704ˆ
	(72226.191)	(67152.261)	(51093.840)	(80686.906)	(1.23e+05)	(79314.798)	(15.224)	(14.809)	(13.626)	(14.733)	(19.154)	(21.946)
R^2	0.375	0.375	0.375	0.383	0.375	0.373	0.443	0.444	0.444	0.445	0.444	0.443
Observations	5,959	5,959	5,959	5,613	5,959	5,959	31,268	31,268	31,268	30,072	31,268	31,268
Zimbabwe	-3.49e+05	-4.46e+05	-3.91e+05	-5.88e+05	-2.43e+06ˆ	15991.137	478.868	348.717	114.517	27.848	-985.783*	634.836*
	(7.60e+05)	(7.11e+05)	(4.97e+05)	(4.68e+05)	(1.32e+06)	(6.35e+05)	(303.281)	(284.559)	(203.530)	(317.195)	(424.064)	(280.540)
R^2	0.242	0.242	0.242	0.242	0.237	0.242	0.475	0.475	0.475	0.475	0.473	0.474
Observations	10,070	10,070	10,070	9,996	10,070	10,070	34,349	34,349	34,349	34,112	34,349	34,349

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is an adult woman (columns 1-6) and an adult (columns 7-12). All estimates include fixed effects for year of birth, DHS cluster, and survey year as well as exposure-by-region, age-by-PfPR, cohort-by-region, exposure since 1998-by-PfPR and individual covariates (age, gender, wealth). All columns control for: . Standard errors (in parentheses) are clustered at the DHS cluster level. ˆ, *, ** and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 6: Descriptive statistics

		Mean (1)	SD (2)	Obs. (3)	Min (4)	Max (5)		Mean (6)	SD (7)	Obs. (8)	Min (9)	Max (10)
Burkina Faso	Grade	3.31	1.69	16,178	0.00	6.00	**Mali**	3.28	1.67	22,256	0.00	6.00
	Years	2.82	1.75	16,177	0.00	6.00		2.38	1.69	22,246	0.00	13.00
	Delay	0.37	0.48	16,178.	0.00	1.00		0.37	0.48	22,256	0.00	1.00
	Exposure to RBM	0.35	0.26	16,180	0.00	0.87		0.37	0.50	22,260	0.00	1.63
	PfPr in 2000	0.63	0.18	904	0.10	0.94		0.31	0.19	1,152	0.04	0.84
	Male	0.54	0.50	16,179	0.00	1.00		0.55	0.50	22,258	0.00	1.00
	Age	10.20	2.61	16,180	5.00	24.00		9.88	2.72	22,260	5.00	24.00
	Wealth	3.45	1.36	16,180	1.00	5.00		3.43	1.41	22,260	1.00	5.00
Cameroon	Grade	3.27	1.75	26,682	0.00	7.00	**Namibia**	3.90	1.98	14,992	0.00	8.00
	Years	2.33	1.76	26,681	0.00	12.00		3.03	2.00	14,985	0.00	15.00
	Delay	0.39	0.49	26,682	0.00	1.00		0.30	0.46	14,992	0.00	1.00
	Exposure to RBM	0.32	0.30	26,685	0.00	1.06		0.22	0.23	14,995	0.00	0.84
	PfPr in 2000	0.42	0.23	1,033	0.04	0.89		0.06	0.02	722	0.03	0.13
	Male	0.53	0.50	26,677	0.00	1.00		0.50	0.50	14,993	0.00	1.00
	Age	9.54	3.12	26,685	3.00	24.00		10.58	2.93	14,995	3.00	24.00
	Wealth	2.92	1.31	26,685	1.00	5.00		2.85	1.39	14,995	1.00	5.00
Ethiopia	Grade	3.28	2.00	33,546	0.00	8.00	**Nigeria**	3.19	1.65	55,978	0.00	6.00
	Years	2.35	2.01	33,548	0.00	8.00		2.26	1.67	55,968	0.00	12.00
	Delay	0.43	0.50	33,546	0.00	1.00		0.41	0.49	55,978	0.00	1.00
	Exposure to RBM	0.21	0.21	33,553	0.00	0.75		0.10	0.06	28,898	0.00	0.21
	PfPr in 2000	0.05	0.03	1,581	0.01	0.31		0.45	0.27	2,057	0.02	0.98
	Male	0.53	0.50	33,553	0.00	1.00		0.53	0.50	55,975	0.00	1.00
	Age	11.98	3.72	33,553	5.00	24.00		9.43	2.83	55,982	5.00	24.00
	Wealth	3.30	1.50	33,553	1.00	5.00		3.11	1.29	55,982	1.00	5.00
Ghana	Grade	3.27	1.67	13,043	0.00	10.00	**Rwanda**	2.78	1.62	24,921	0.00	8.00
	Years	2.32	1.68	13,043	0.00	7.00		2.15	1.70	24,887	0.00	10.00
	Delay	0.39	0.49	13,043	0.00	1.00		0.50	0.50	24,921	0.00	1.00
	Exposure to RBM	0.21	0.17	13,044	0.00	0.79		1.07	0.95	24,922	0.05	4.03
	PfPr in 2000	0.57	0.23	804	0.09	0.92		0.22	0.13	961	0.06	0.59
	Male	0.52	0.50	13,044	0.00	1.00		0.50	0.50	24,922	0.00	1.00
	Age	10.21	2.87	13,044	3.00	24.00		11.17	3.16	24,922	3.00	24.00
	Wealth	2.70	1.39	13,044	1.00	5.00		3.05	1.41	24,922	1.00	5.00
Guinea	Grade	2.82	1.69	12,623	0.00	6.00	**Senegal**	3.24	1.71	20,983	0.00	6.00
	Years	2.36	1.67	12,623	0.00	15.00		2.30	1.72	20,978	0.00	12.00
	Delay	0.48	0.50	12,623	0.00	1.00		0.40	0.49	20,983	0.00	1.00
	Exposure to RBM	0.34	0.28	12,624	0.02	1.32		0.63	0.63	20,992	0.01	1.94
	PfPr in 2000	0.33	0.18	583	0.09	0.81		0.20	0.12	742	0.05	0.64
	Male	0.55	0.50	12,624	0.00	1.00		0.50	0.50	20,992	0.00	1.00
	Age	10.52	2.94	12,624	3.00	24.00		10.17	2.91	20,992	5.00	24.00
	Wealth	3.42	1.33	12,624	1.00	5.00		2.73	1.29	20,992	1.00	5.00
Kenya	Grade	4.13	2.29	18,671	0.00	11.00	**Uganda**	3.28	1.90	35,240	0.00	7.00
	Years	3.48	2.34	18,669	0.00	12.00		2.44	1.92	35,236	0.00	12.00

	Delay	0.30	0.46	18,671	0.00	1.00		Delay	0.41	0.49	35,240	0.00	1.00
	Exposure to RBM	0.21	0.22	18,672	0.00	1.03		Exposure to RBM	0.40	0.40	35,256	0.00	1.53
	PfPr in 2000	0.18	0.19	790	0.02	0.79		PfPr in 2000	0.50	0.23	1,002	0.08	0.86
	Male	0.52	0.50	18,672	0.00	1.00		Male	0.51	0.50	35,256	0.00	1.00
	Age	11.41	3.39	18,672	4.00	24.00		Age	10.78	3.23	35,256	3.00	24.00
	Wealth	2.86	1.38	18,672	1.00	5.00		Wealth	3.06	1.42	35,256	1.00	5.00
Malawi	Grade	3.41	2.15	69,895	0.00	8.00	**Zimbabwe**	Grade	3.82	2.00	24,223	0.00	7.00
	Years	2.77	2.17	69,887	0.00	12.00		Years	3.00	2.05	24,215	0.00	13.00
	Delay	0.42	0.49	69,895	0.00	1.00		Delay	0.32	0.47	24,223	0.00	1.00
	Exposure to RBM	0.45	0.47	69,898	0.00	1.52		Exposure to RBM	0.19	0.23	24,225	0.00	0.88
	PfPr in 2000	0.32	0.14	1,919	0.08	0.76		PfPr in 2000	0.02	0.02	1,018	0.01	0.24
	Male	0.51	0.50	69,898	0.00	1.00		Male	0.51	0.50	24,225	0.00	1.00
	Age	10.80	3.49	69,898	5.00	24.00		Age	9.91	2.51	24,225	3.00	24.00
	Wealth	3.04	1.39	69,898	1.00	5.00		Wealth	2.67	1.37	24,225	1.00	5.00

Table 7: Impact of RBM's anti-malaria campaign on primary students' educational outcomes: OLS estimates for grade

	Grade						Grade				
	(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)	(10)
Burkina Faso	2.501***	11.835***	17.745***	22.966***	28.330***	**Mali**	0.535	2.191*	2.616***	3.130***	4.479***
	(0.749)	(1.298)	(1.450)	(1.592)	(2.365)		(0.360)	(0.718)	(0.784)	(0.888)	(1.043)
R^2	0.668	0.677	0.681	0.687	0.687	R^2	0.642	0.644	0.644	0.645	0.645
Observations	15,448	15,448	15,448	15,448	15,448	Observations	22,208	22,208	22,208	22,208	22,208
Cameroon	0.509	5.330***	6.082***	5.871***	1.542	**Namibia**	51.227***	54.239***	42.139*	29.152ˆ	19.528
	(0.341)	(0.586)	(0.625)	(0.765)	(0.978)		(6.700)	(14.628)	(15.578)	(17.123)	(17.225)
R^2	0.660	0.665	0.665	0.668	0.669	R^2	0.722	0.725	0.725	0.728	0.731
Observations	26,618	26,618	26,618	26,618	26,618	Observations	14,838	14,838	14,838	14,838	14,838
Ethiopia	15.652*	12.344*	35.569***	16.701*	18.363*	**Nigeria**	2.508*	8.471***	20.886***	21.206***	25.685***
	(4.753)	(6.197)	(7.315)	(8.497)	(8.064)		(1.240)	(1.396)	(1.957)	(2.189)	(2.900)
R^2	0.545	0.551	0.551	0.553	0.553	R^2	0.533	0.537	0.539	0.541	0.541
Observations	32,802	32,802	32,802	32,802	32,802	Observations	28,837	28,837	28,837	28,837	28,837
Ghana	9.306***	8.211***	11.177***	13.525***	15.187***	**Rwanda**	0.703***	0.612*	0.295	0.313	0.667
	(0.891)	(1.204)	(1.313)	(1.510)	(1.821)		(0.154)	(0.279)	(0.324)	(0.346)	(0.496)
R^2	0.599	0.602	0.603	0.606	0.606	R^2	0.670	0.671	0.671	0.671	0.671
Observations	12,835	12,835	12,835	12,835	12,835	Observations	24,801	24,801	24,801	24,801	24,801
Guinea	2.080***	2.355*	3.951*	5.903***	6.051*	**Senegal**	2.805***	2.017***	1.792*	1.607*	4.258***
	(0.618)	(1.081)	(1.216)	(1.536)	(2.042)		(0.384)	(0.548)	(0.651)	(0.685)	(1.047)
R^2	0.618	0.618	0.618	0.619	0.619	R^2	0.624	0.627	0.627	0.630	0.630
Observations	12,509	12,509	12,509	12,509	12,509	Observations	20,575	20,575	20,575	20,575	20,575
Kenya	3.597***	1.780	0.018	2.227	2.566	**Uganda**	1.074***	0.154	0.617	1.034*	0.618
	(0.666)	(1.212)	(1.353)	(1.589)	(1.644)		(0.258)	(0.349)	(0.427)	(0.460)	(0.497)
R^2	0.724	0.730	0.730	0.731	0.731	R^2	0.699	0.702	0.702	0.703	0.703
Observations	18,557	18,557	18,557	18,557	18,557	Observations	32,746	32,746	32,746	32,746	32,746
Malawi	0.861***	0.227	-0.436	-0.078	0.179	**Zimbabwe**	50.513***	46.770***	12.922	11.880	16.748
	(0.208)	(0.240)	(0.312)	(0.346)	(0.381)		(10.448)	(11.788)	(15.396)	(15.538)	(15.137)
R^2	0.703	0.704	0.704	0.704	0.704	R^2	0.762	0.762	0.763	0.765	0.765
Observations	68,995	68,995	68,995	68,995	68,995	Observations	23,759	23,759	23,759	23,759	23,759
Exposure*Region FE	no	yes	yes	yes	yes		no	yes	yes	yes	yes
Age*PfPR	no	no	yes	yes	yes		no	no	yes	yes	yes
Year of birth*Region FE	no	no	no	yes	yes		no	no	no	yes	yes
Exposure from 1998*PfPR	no	no	no	no	yes		no	no	no	no	yes

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is the primary school student. The dependent variable "Grade" stands for grade level during the year when the interview is conducted. All estimates include fixed effects for cohort, cluster, and survey year as well as individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ˆ, *, **, and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 8: Impact of RBM's anti-malaria campaign on primary students' educational outcomes: OLS estimates for years

	Years						Years				
	(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)	(10)
Burkina Faso	2.503*	11.573***	17.530***	22.464***	27.849***	**Mali**	0.623ˆ	2.052*	2.605***	3.297***	4.204***
	(0.771)	(1.335)	(1.468)	(1.607)	(2.406)		(0.359)	(0.715)	(0.788)	(0.899)	(1.077)
R^2	0.682	0.690	0.695	0.700	0.700	R^2	0.640	0.642	0.642	0.643	0.643
Observations	15,447	15,447	15,447	15,447	15,447	Observations	22,198	22,198	22,198	22,198	22,198
Cameroon	0.343	5.100***	5.877***	5.347***	1.049	**Namibia**	48.359***	52.041***	41.718*	30.603ˆ	21.433
	(0.331)	(0.569)	(0.608)	(0.766)	(1.005)		(6.507)	(14.150)	(15.017)	(16.563)	(16.638)
R^2	0.661	0.666	0.666	0.669	0.670	R^2	0.718	0.721	0.721	0.724	0.726
Observations	26,617	26,617	26,617	26,617	26,617	Observations	14,831	14,831	14,831	14,831	14,831
Ethiopia	15.593*	11.944ˆ	34.625***	14.918ˆ	16.546*	**Nigeria**	2.680*	8.402***	19.620***	19.048***	23.168***
	(4.752)	(6.179)	(7.308)	(8.484)	(8.033)		(1.293)	(1.436)	(2.078)	(2.264)	(2.987)
R^2	0.547	0.552	0.553	0.554	0.555	R^2	0.548	0.551	0.553	0.554	0.554
Observations	32,804	32,804	32,804	32,804	32,804	Observations	28,831	28,831	28,831	28,831	28,831
Ghana	9.329***	8.217***	11.197***	13.476***	15.042***	**Rwanda**	0.677***	0.633*	0.259	0.427	0.622
	(0.884)	(1.202)	(1.316)	(1.498)	(1.829)		(0.161)	(0.305)	(0.348)	(0.376)	(0.525)
R^2	0.606	0.609	0.610	0.613	0.613	R^2	0.691	0.692	0.692	0.692	0.692
Observations	12,835	12,835	12,835	12,835	12,835	Observations	24,777	24,777	24,777	24,777	24,777
Guinea	2.821***	3.051*	4.914***	6.876***	7.625***	**Senegal**	2.687***	1.930***	1.705*	1.153	3.303*
	(0.570)	(1.076)	(1.199)	(1.503)	(1.996)		(0.394)	(0.564)	(0.665)	(0.702)	(1.055)
R^2	0.617	0.617	0.617	0.618	0.618	R^2	0.625	0.628	0.628	0.631	0.631
Observations	12,509	12,509	12,509	12,509	12,509	Observations	20,570	20,570	20,570	20,570	20,570
Kenya	3.350***	1.097	-0.856	1.409	1.726	**Uganda**	1.047***	0.109	0.400	1.159*	0.637
	(0.663)	(1.198)	(1.335)	(1.562)	(1.633)		(0.264)	(0.356)	(0.446)	(0.472)	(0.514)
R^2	0.733	0.738	0.739	0.740	0.740	R^2	0.705	0.708	0.708	0.709	0.709
Observations	18,555	18,555	18,555	18,555	18,555	Observations	32,742	32,742	32,742	32,742	32,742
Malawi	0.807***	0.107	-0.827*	-0.324	-0.173	**Zimbabwe**	48.810***	46.299*	12.880	13.403	18.230
	(0.220)	(0.255)	(0.329)	(0.364)	(0.395)		(14.483)	(15.873)	(18.140)	(18.342)	(18.421)
R^2	0.705	0.705	0.705	0.706	0.706	R^2	0.766	0.767	0.767	0.769	0.769
Observations	68,987	68,987	68,987	68,987	68,987	Observations	23,751	23,751	23,751	23,751	23,751
Exposure*Region FE	no	yes	yes	yes	yes		no	yes	yes	yes	yes
Age*PfPR	no	no	yes	yes	yes		no	no	yes	yes	yes
Year of birth*Region FE	no	no	no	yes	yes		no	no	no	yes	yes
Exposure from 1998*PfPR	no	no	no	no	yes		no	no	no	no	yes

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is the primary school student. The dependent variable "Years" stands for the total years of schooling. All estimates include fixed effects for cohort, cluster, and survey year as well as individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ˆ, *, **, and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 9: Impact of RBM's anti-malaria campaign on primary students' educational outcomes: OLS estimates for delay

	Delay						Delay				
	(1)	(2)	(3)	(4)	(5)		(6)	(7)	(8)	(9)	(10)
Burkina Faso	-0.462*	-2.832***	-4.319***	-5.715***	-5.973***	**Mali**	-0.010	-0.675***	-0.788***	-0.948***	-1.812***
	(0.210)	(0.337)	(0.345)	(0.370)	(0.547)		(0.103)	(0.199)	(0.221)	(0.260)	(0.299)
R^2	0.555	0.564	0.567	0.573	0.573	R^2	0.508	0.510	0.510	0.511	0.512
Observations	15,448	15,448	15,448	15,448	15,448	Observations	22,208	22,208	22,208	22,208	22,208
Cameroon	-0.325***	-1.415***	-1.745***	-2.204***	0.151	**Namibia**	-22.250***	-28.979***	-30.985***	-26.802***	-24.160***
	(0.076)	(0.163)	(0.174)	(0.222)	(0.289)		(1.840)	(4.334)	(4.364)	(4.934)	(5.033)
R^2	0.543	0.547	0.547	0.550	0.552	R^2	0.574	0.577	0.577	0.581	0.584
Observations	26,618	26,618	26,618	26,618	26,618	Observations	14,838	14,838	14,838	14,838	14,838
Ethiopia	-5.320***	-8.064***	-17.118***	-13.664***	-13.862***	**Nigeria**	-2.335***	-3.785***	-7.424***	-8.228***	-9.166***
	(1.042)	(1.721)	(2.150)	(2.286)	(2.363)		(0.325)	(0.371)	(0.557)	(0.670)	(0.857)
R^2	0.393	0.399	0.402	0.404	0.405	R^2	0.418	0.421	0.423	0.426	0.426
Observations	32,802	32,802	32,802	32,802	32,802	Observations	28,837	28,837	28,837	28,837	28,837
Ghana	-2.715***	-2.653***	-4.736***	-5.406***	-5.141***	**Rwanda**	-0.406***	-0.792***	-0.953***	-0.771***	-0.806***
	(0.239)	(0.336)	(0.372)	(0.453)	(0.543)		(0.045)	(0.109)	(0.118)	(0.118)	(0.155)
R^2	0.477	0.480	0.484	0.487	0.487	R^2	0.543	0.547	0.547	0.550	0.550
Observations	12,835	12,835	12,835	12,835	12,835	Observations	24,801	24,801	24,801	24,801	24,801
Guinea	-0.649***	-1.330***	-2.131***	-2.841***	-1.905*	**Senegal**	-1.086***	-0.703***	-1.070***	-0.902***	-1.057***
	(0.188)	(0.363)	(0.396)	(0.485)	(0.699)		(0.104)	(0.140)	(0.169)	(0.187)	(0.296)
R^2	0.475	0.477	0.477	0.478	0.478	R^2	0.519	0.523	0.523	0.527	0.527
Observations	12,509	12,509	12,509	12,509	12,509	Observations	20,575	20,575	20,575	20,575	20,575
Kenya	-1.612***	-0.790*	-1.172***	-0.738*	-0.725*	**Uganda**	-0.719***	-0.288*	-0.740***	-0.916***	-0.596***
	(0.153)	(0.256)	(0.293)	(0.339)	(0.342)		(0.076)	(0.089)	(0.117)	(0.134)	(0.154)
R^2	0.502	0.527	0.527	0.533	0.533	R^2	0.530	0.536	0.537	0.540	0.541
Observations	18,557	18,557	18,557	18,557	18,557	Observations	32,746	32,746	32,746	32,746	32,746
Malawi	-0.720***	-0.663***	-1.361***	-1.101***	-1.128***	**Zimbabwe**	-10.589***	-9.586*	-13.000*	-12.432*	-14.037***
	(0.052)	(0.067)	(0.083)	(0.091)	(0.101)		(2.432)	(2.974)	(4.019)	(3.956)	(4.213)
R^2	0.540	0.540	0.542	0.544	0.544	R^2	0.586	0.589	0.589	0.590	0.591
Observations	68,995	68,995	68,995	68,995	68,995	Observations	23,759	23,759	23,759	23,759	23,759
Exposure*Region FE	no	yes	yes	yes	yes		no	yes	yes	yes	yes
Age*PfPR	no	no	yes	yes	yes		no	no	yes	yes	yes
Year of birth*Region FE	no	no	no	yes	yes		no	no	no	yes	yes
Exposure from 1998*PfPR	no	no	no	no	yes		no	no	no	no	yes

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is the primary school student. The dependent variable "Delay" stands for delay status for grade level. All estimates include fixed effects for cohort, cluster, and survey year as well as individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ^, *, ** and *** indicate significance at the 10, 5, 1 and 0.1% levels.

Table 10: Impact of RBM's campaign on primary students' educational outcomes: IV estimates for grade

	Grade							Grade					
	Set I	Set II	Set III	Set IV	Set V	Set VI		Set I	Set II	Set III	Set IV	Set V	Set VI
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
Burkina Faso	66.349***	69.906***	56.608***	41.293***	63.320***	66.744***	**Mali**	16.139***	31.217***	12.295***	8.173***	28.030***	6.141***
	(4.539)	(4.525)	(5.189)	(4.024)	(4.659)	(4.482)		(3.865)	(4.309)	(2.351)	(1.805)	(4.342)	(1.790)
R^2	0.673	0.669	0.674	0.686	0.674	0.672	R^2	0.640	0.618	0.642	0.643	0.624	0.645
Observations	15,448	15,448	15,448	15,448	15,448	15,448	Observations	22,208	22,208	22,208	21,905	22,208	22,208
DWH χ^2	253.87***	366.668***	20.436***	26.7543***	219.725***	247.071***	DWH χ^2	22.4013***	139.45***	35.4197***	13.8951***	157.899***	1.51551
Cameroon	9.723*	11.713***	4.940^	14.595***	54.162***	15.569*	**Namibia**	158.298***	164.785***	150.343***	211.423***	165.695***	175.121***
	(3.807)	(3.469)	(2.674)	(4.143)	(13.421)	(5.631)		(27.125)	(26.450)	(24.527)	(36.250)	(32.562)	(41.775)
R^2	0.668	0.667	0.669	0.666	0.619	0.665	R^2	0.728	0.727	0.728	0.709	0.728	0.727
Observations	26,591	26,591	26,591	26,569	26,618	26,618	Observations	14,733	14,733	14,733	10,967	14,838	14,838
DWH χ^2	9.62249***	16.9888***	2.9644***	25.8562***	78.5738***	12.2571***	DWH χ^2	70.21***	84.8419***	86.0124***	52.9826***	43.7214***	43.8716***
Ethiopia	256.576***	239.641***	106.021***	185.278***	210.506***	248.735	**Nigeria**	128.530***	148.985***	82.395***	65.222***	107.502***	133.584***
	(43.904)	(40.702)	(22.116)	(38.479)	(58.895)	(162.870)		(13.006)	(12.392)	(6.637)	(9.018)	(10.348)	(19.019)
R^2	0.531	0.534	0.550	0.552	0.539	0.532	R^2	0.502	0.485	0.529	0.535	0.516	0.498
Observations	32,802	32,802	32,802	26,919	32,802	32,802	Observations	28,837	28,837	28,837	28,837	28,837	28,837
DWH χ^2	121.235***	137.036***	63.2621***	75.5724***	44.3767***	0.80365	DWH χ^2	216.643***	498.722***	244.082***	40.5173***	200.16***	114.32***
Ghana	59.289***	61.230***	35.338***	64.256***	55.532***	34.795***	**Rwanda**	1.392	1.502	-0.638	4.632*	0.832	0.234
	(7.044)	(5.710)	(3.810)	(6.423)	(10.659)	(7.450)		(1.462)	(1.498)	(1.012)	(1.513)	(2.790)	(6.263)
R^2	0.580	0.577	0.601	0.573	0.584	0.601	R^2	0.671	0.671	0.671	0.674	0.671	0.671
Observations	12,781	12,781	12,781	12,827	12,835	12,835	Observations	24,801	24,801	24,801	19,155	24,801	24,801
DWH χ^2	123.541***	168.616***	61.845***	177.103***	35.9611***	14.0124***	DWH χ^2	0.484962	0.615846	3.34724^	6.64333**	0.00532	0.006551
Guinea	52.903*	133.409***	32.332*	1.476	199.075	-166.139^	**Senegal**	180.108***	147.513***	20.262***	83.634***	65.469***	3.132
	(23.250)	(30.502)	(10.205)	(8.167)	(181.033)	(98.444)		(37.882)	(34.609)	(4.454)	(15.857)	(15.499)	(5.025)
R^2	0.600	0.483	0.613	0.618	0.305	0.369	R^2	.	0.128	0.623	0.477	0.539	0.630
Observations	12,390	12,390	12,390	12,467	12,509	12,509	Observations	20,442	20,442	20,442	20,575	20,575	20,575
DWH χ^2	10.9321***	75.0614***	14.5954***	0.233242	15.1594***	21.7337***	DWH χ^2	234.294***	195.628***	25.9156***	132.852***	77.4894***	-8.13117
Kenya	30.282***	31.169*	7.303^	-4.315	8.937	-1.770	**Uganda**	4.627*	3.526*	0.182	3.107	-4.112	0.678
	(9.135)	(9.886)	(4.100)	(3.288)	(13.240)	(3.364)		(2.210)	(1.439)	(1.141)	(2.990)	(3.936)	(1.823)
R^2	0.723	0.723	0.730	0.721	0.731	0.731	R^2	0.702	0.702	0.703	0.703	0.701	0.703
Observations	18,503	18,503	18,503	15,895	18,557	18,557	Observations	32,746	32,746	32,746	31,497	32,746	32,746
DWH χ^2	23.7101***	24.9725***	3.16343^	7.98147***	0.577644	0.649948	DWH χ^2	7.88189**	7.76115**	-3.51849	0.809648	-1.91067	-3.42264
Malawi	3.889*	3.506*	0.999	5.008***	3.741*	-1.379	**Zimbabwe**	137.657***	137.559***	67.882*	105.601*	466.017*	100.789*
	(1.307)	(1.193)	(0.619)	(1.319)	(1.818)	(1.170)		(39.433)	(37.692)	(22.456)	(34.586)	(155.258)	(31.797)
R^2	0.703	0.704	0.704	0.703	0.704	0.704	R^2	0.762	0.762	0.764	0.763	0.730	0.763
Observations	68,995	68,995	68,995	68,995	68,995	68,995	Observations	23,759	23,759	23,759	23,603	23,759	23,759
DWH χ^2	17.8848***	17.4337***	4.25216*	34.977***	8.83961***	2.97191^	DWH χ^2	45.0543***	61.1183***	28.979***	46.1164***	49.3683***	34.5475***

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is the primary school student. The dependent variable "Grade" stands for grade level during the year when the interview is conducted. All estimates include fixed effects for cohort, cluster, and survey year as well as exposure-by-region, age-by-PfPR, cohort-by-region, exposure since 1998-by-PfPR, and individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. *** denotes significance at the 1% level, ** at the 5% level, * at the 10% level, and ^ at the 15% level.

Table 11: Impact of RBM's campaign on primary students' educational outcomes: IV estimates for years

	Years							Years					
	Set I	Set II	Set III	Set IV	Set V	Set VI		Set I	Set II	Set III	Set IV	Set V	Set VI
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
Burkina Faso	76.563***	79.982***	59.996***	45.202***	74.856***	64.526***	**Mali**	18.356***	31.924***	11.562***	7.456***	26.603***	6.311***
	(5.648)	(5.409)	(6.818)	(4.503)	(5.544)	(4.326)		(4.127)	(4.373)	(2.357)	(1.801)	(4.299)	(1.885)
R^2	0.677	0.674	0.682	0.697	0.679	0.687	R^2	0.635	0.614	0.641	0.641	0.624	0.642
Observations	15,447	15,447	15,447	15,447	15,447	15,447	Observations	22,198	22,198	22,198	21,895	22,198	22,198
DWH χ^2	205.811***	376.775***	-110.413	18.2215***	238.989***	245.68***	DWH χ^2	31.7943***	144.396***	30.2533***	10.4817**	137.606***	3.53677^
Cameroon	8.425*	10.445*	4.363	14.212***	49.997***	15.108*	**Namibia**	149.145***	156.575***	144.036***	206.301***	162.724***	176.856***
	(3.762)	(3.477)	(2.678)	(3.734)	(12.597)	(5.281)		(26.824)	(26.150)	(24.504)	(35.103)	(32.084)	(41.190)
R^2	0.669	0.668	0.670	0.667	0.627	0.667	R^2	0.724	0.724	0.725	0.708	0.724	0.723
Observations	26,590	26,590	26,590	26,568	26,617	26,617	Observations	14,726	14,726	14,726	10,964	14,831	14,831
DWH χ^2	7.83418**	13.8353***	2.92116^	26.4173***	69.4325***	12.3016***	DWH χ^2	57.7384***	71.3244***	73.3893***	47.5931***	39.5495***	42.3648***
Ethiopia	251.276***	235.166***	104.258***	181.350***	203.996***	691.873	**Nigeria**	115.612***	128.740***	74.017***	69.311***	89.198***	117.226***
	(44.078)	(40.475)	(22.184)	(38.690)	(58.660)	(1207.235)		(13.075)	(11.912)	(6.777)	(9.840)	(10.547)	(19.133)
R^2	0.534	0.536	0.552	0.553	0.541	0.376	R^2	0.525	0.516	0.545	0.547	0.539	0.524
Observations	32,804	32,804	32,804	26,920	32,804	32,804	Observations	28,831	28,831	28,831	28,831	28,831	28,831
DWH χ^2	116.591***	134.09***	63.0691***	73.6684***	41.5934***	2.27999	DWH χ^2	170.246***	355.483***	190.862***	53.6553***	126.772***	84.4441***
Ghana	59.170***	60.598***	34.567***	63.152***	51.619***	34.867***	**Rwanda**	2.562^	2.631^	-0.306	5.539***	2.493	-0.881
	(6.963)	(5.616)	(3.778)	(6.370)	(9.731)	(7.708)		(1.535)	(1.574)	(1.052)	(1.637)	(3.012)	(6.646)
R^2	0.587	0.585	0.608	0.582	0.595	0.608	R^2	0.692	0.692	0.692	0.694	0.692	0.692
Observations	12,781	12,781	12,781	12,827	12,835	12,835	Observations	24,777	24,777	24,777	19,133	24,777	24,777
DWH χ^2	126.638***	167.169***	62.2582***	170.578***	34.6907***	14.1566***	DWH χ^2	3.35861^	3.45349^	1.64413	12.6869***	0.656232	0.076769
Guinea	61.027*	128.006***	35.590***	2.833	168.995	-136.948	**Senegal**	171.986***	141.300***	18.408***	80.377***	61.876***	1.997
	(23.501)	(29.341)	(9.806)	(8.059)	(152.704)	(85.348)		(36.046)	(33.006)	(4.382)	(15.284)	(15.283)	(5.557)
R^2	0.593	0.494	0.611	0.617	0.394	0.438	R^2	.	0.167	0.624	0.487	0.548	0.631
Observations	12,390	12,390	12,390	12,467	12,509	12,509	Observations	20,437	20,437	20,437	20,570	20,570	20,570
DWH χ^2	14.4847***	68.2871***	16.7977***	0.259822	10.8358***	15.6016***	DWH χ^2	220.265***	184.672***	23.1096***	125.981***	71.3478***	-8.03886
Kenya	27.754*	29.882*	6.400	-7.279*	11.874	103.368	**Uganda**	5.131*	3.724*	0.081	3.335	-3.443	0.745
	(8.956)	(9.994)	(4.176)	(3.338)	(12.792)	(218.207)		(2.308)	(1.499)	(1.159)	(3.026)	(3.940)	(1.845)
R^2	0.733	0.732	0.739	0.730	0.739	0.643	R^2	0.708	0.708	0.709	0.710	0.708	0.709
Observations	18,501	18,501	18,501	15,893	18,555	18,555	Observations	32,742	32,742	32,742	31,493	32,742	32,742
DWH χ^2	23.1872***	24.3335***	2.97787^	13.3977***	1.15277	4.50122*	DWH χ^2	9.33602**	6.46545	0.890462	1.34558	2.93423^	-3.74719
Malawi	2.967*	2.415*	0.560	4.819***	1.346	-2.201^	**Zimbabwe**	124.392***	122.290***	68.539*	134.687***	385.302*	96.235***
	(1.349)	(1.213)	(0.639)	(1.352)	(1.932)	(1.253)		(34.144)	(31.985)	(22.454)	(36.537)	(131.289)	(27.877)
R^2	0.705	0.705	0.706	0.704	0.706	0.705	R^2	0.767	0.767	0.768	0.766	0.747	0.768
Observations	68,987	68,987	68,987	68,987	68,987	68,987	Observations	23,751	23,751	23,751	23,596	23,751	23,751
DWH χ^2	12.3422***	10.6367**	3.35114^	37.1213***	1.52422	5.01859*	DWH χ^2	33.7062***	44.025***	27.2823***	77.1556***	31.1151***	28.9344***

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is the primary school student. The dependent variable "Years" stands for the total years of schooling. All estimates include fixed effects for cohort, cluster, and survey year as well as exposure-by-region, age-by-PfPR, cohort-by-region, exposure since 1998-by-PfPR, and individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ^, *, ** and *** indicate significance at the 15%, 10%, 5% and 1% levels.

Table 12: Impact of RBM's campaign on primary students' educational outcomes: IV estimates for delay

	Delay							Delay					
	Set I	Set II	Set III	Set IV	Set V	Set VI		Set I	Set II	Set III	Set IV	Set V	Set VI
	(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)	(12)
Burkina Faso	-16.255***	-17.242***	-13.961***	-8.267***	-15.515***	-16.699***	**Mali**	-7.092***	-13.342***	-5.311***	-2.990***	-11.881***	-1.564*
	(1.229)	(1.232)	(1.379)	(0.951)	(1.236)	(1.245)		(1.277)	(1.418)	(0.762)	(0.530)	(1.419)	(0.553)
R^2	0.560	0.557	0.560	0.573	0.561	0.559	R^2	0.500	0.452	0.507	0.511	0.466	0.512
Observations	15,448	15,448	15,448	15,448	15,448	15,448	Observations	22,208	22,208	22,208	21,905	22,208	22,208
DWH χ^2	167.254***	241.702***	-8.11812	7.75277**	146.935***	172.282***	DWH χ^2	39.681***	223.982***	61.3205***	12.519***	249.283***	-13.3262
Cameroon	-3.851***	-5.595***	-3.257***	-4.050***	-28.046***	-4.964*	**Namibia**	-102.379***	-101.906***	-86.576***	-89.194***	-110.595***	-102.966***
	(1.159)	(1.171)	(0.906)	(1.080)	(5.569)	(1.599)		(7.414)	(7.038)	(7.117)	(11.047)	(11.111)	(13.320)
R^2	0.549	0.545	0.550	0.548	0.368	0.546	R^2	0.568	0.568	0.574	0.557	0.564	0.568
Observations	26,591	26,591	26,591	26,569	26,618	26,618	Observations	14,733	14,733	14,733	10,967	14,838	14,838
DWH χ^2	22.0718***	51.3805***	28.0498***	25.224***	217.816***	14.8749***	DWH χ^2	272.982***	297.286***	239.708***	88.5971***	184.85***	136.071***
Ethiopia	-171.449***	-147.241***	-64.811***	-141.374***	-147.851***	-160.050*	**Nigeria**	-45.823***	-59.988***	-31.729***	-22.957***	-46.584***	-53.344***
	(17.015)	(15.236)	(7.774)	(18.075)	(24.620)	(73.983)		(3.930)	(4.439)	(2.122)	(2.658)	(3.492)	(6.216)
R^2	0.246	0.291	0.388	0.290	0.290	0.268	R^2	0.369	0.316	0.404	0.418	0.366	0.343
Observations	32,802	32,802	32,802	26,919	32,802	32,802	Observations	28,837	28,837	28,837	28,837	28,837	28,837
DWH χ^2	644.442***	604.135***	259.316***	499.456***	260.906***	3.9878*	DWH χ^2	252.85***	778.371***	354.936***	45.2873***	384.609***	176.056***
Ghana	-23.169***	-24.942***	-14.631***	-24.008***	-25.326***	-16.449***	**Rwanda**	-4.910***	-5.034***	-2.372***	-5.761***	-7.817***	-2.348
	(2.552)	(2.096)	(1.195)	(2.213)	(3.978)	(2.160)		(0.549)	(0.563)	(0.377)	(0.616)	(1.333)	(2.203)
R^2	0.435	0.424	0.473	0.430	0.421	0.467	R^2	0.536	0.535	0.548	0.536	0.508	0.548
Observations	12,781	12,781	12,781	12,827	12,835	12,835	Observations	24,801	24,801	24,801	19,155	24,801	24,801
DWH χ^2	187.363***	278.922***	127.33***	238.634***	84.2977***	43.5865***	DWH χ^2	119.01***	121.178***	37.0337***	142.49***	73.2186***	0.638573
Guinea	-27.498*	-56.662***	-13.423***	2.040	-65.718	49.832^	**Senegal**	-83.571***	-68.038***	-6.323***	-35.012***	-28.776***	-2.144
	(9.819)	(12.291)	(3.700)	(2.728)	(56.698)	(29.720)		(16.522)	(15.293)	(1.336)	(6.289)	(5.923)	(1.485)
R^2	0.415	0.190	0.465	0.476	0.086	0.220	R^2	.	.	0.517	0.184	0.298	0.526
Observations	12,390	12,390	12,390	12,467	12,509	12,509	Observations	20,442	20,442	20,442	20,575	20,575	20,575
DWH χ^2	27.5501***	116.175***	23.7608***	1.51936	13.6709***	16.4057***	DWH χ^2	493.463***	409.082***	26.85***	232.739***	152.123***	-4.3949
Kenya	-7.486***	-6.904***	-2.187*	0.377	-23.789*	-0.990	**Uganda**	-7.981***	-5.549***	-2.927***	-10.163***	-15.030***	-4.983*
	(1.933)	(1.926)	(0.832)	(0.659)	(8.207)	(0.774)		(2.036)	(1.432)	(0.464)	(1.884)	(3.476)	(1.701)
R^2	0.522	0.524	0.532	0.545	0.404	0.533	R^2	0.490	0.518	0.536	0.464	0.348	0.523
Observations	18,503	18,503	18,503	15,895	18,557	18,557	Observations	32,746	32,746	32,746	31,497	32,746	32,746
DWH χ^2	20.738***	17.936***	4.56018*	1.46527	83.9699***	-0.017713	DWH χ^2	227.819***	192.69***	81.8028***	328.839***	309.411***	58.5665***
Malawi	-8.855***	-8.481***	-2.754***	-5.941***	-13.359***	-2.104***	**Zimbabwe**	-88.559***	-90.356***	-35.874***	-78.084***	-434.190***	-38.614***
	(0.628)	(0.550)	(0.196)	(0.497)	(1.027)	(0.298)		(19.109)	(19.022)	(8.633)	(22.279)	(111.881)	(9.895)
R^2	0.481	0.487	0.541	0.520	0.387	0.543	R^2	0.573	0.572	0.589	0.577	0.037	0.589
Observations	68,995	68,995	68,995	68,995	68,995	68,995	Observations	23,759	23,759	23,759	23,603	23,759	23,759
DWH χ^2	945.079***	1042.75***	205.028***	425.351***	1297.64***	14.3292***	DWH χ^2	181.005***	257.945***	55.8959***	254.373***	456.618***	31.2468***

Notes: Each cell reports the coefficient of interest from Equation (3). The unit of observation is the primary school student. The dependent variable "Delay" stands for delay status for grade level. All estimates include fixed effects for cohort, cluster, and survey year as well as exposure-by-region, age-by-PfPR, cohort-by-region, exposure since 1998-by-PfPR, and individual covariates (age, gender, wealth). Standard errors (in parentheses) are clustered at the DHS cluster level. ^, *, ** and *** indicate significance at the 10, 5, 1 and 0.1% levels.